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SPE JOURNAL

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- estimating service life of RP structures 977
- mica as a reinforcing material 981
- importance of filament orientation in vessel design 989

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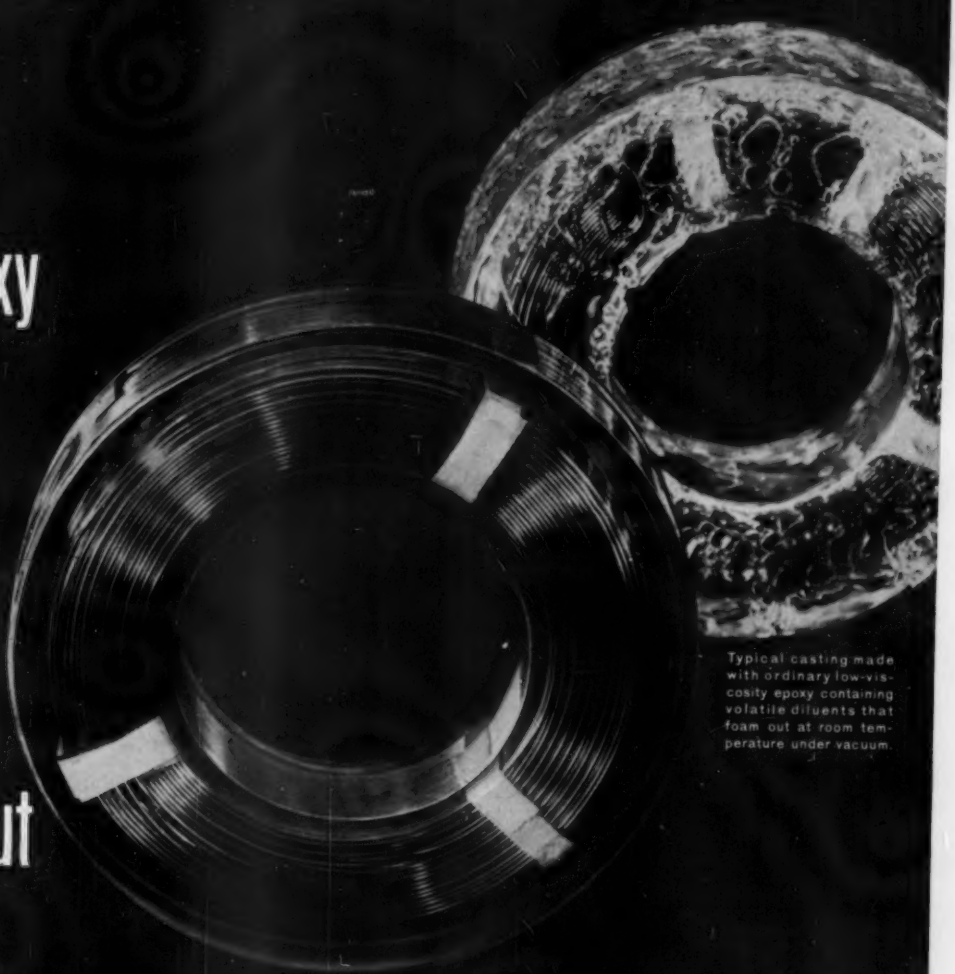

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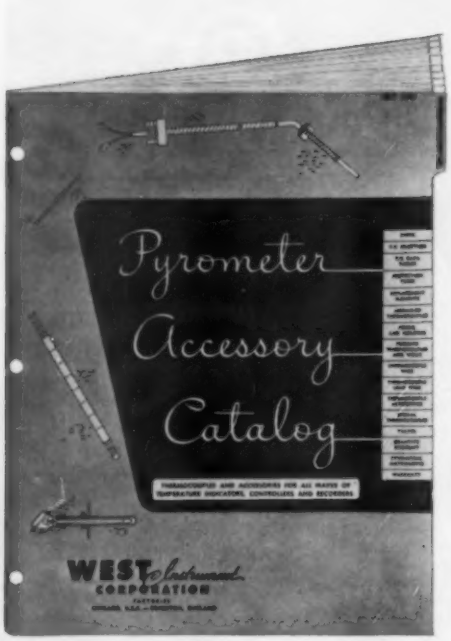

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SPE JOURNAL
VOL. 17 • NO. 9
SEPTEMBER 1961

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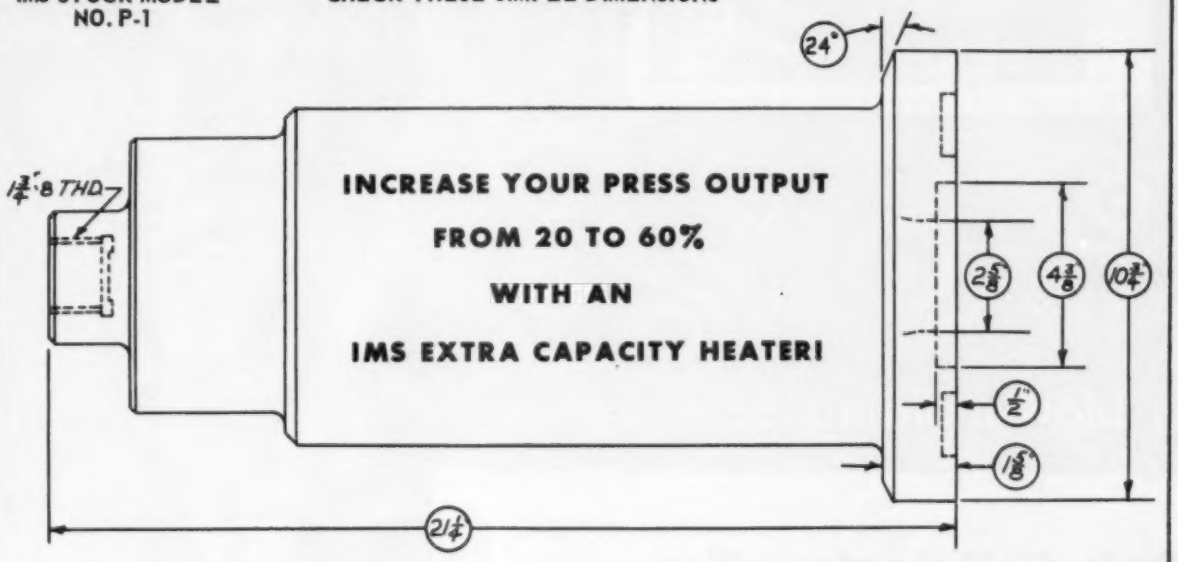

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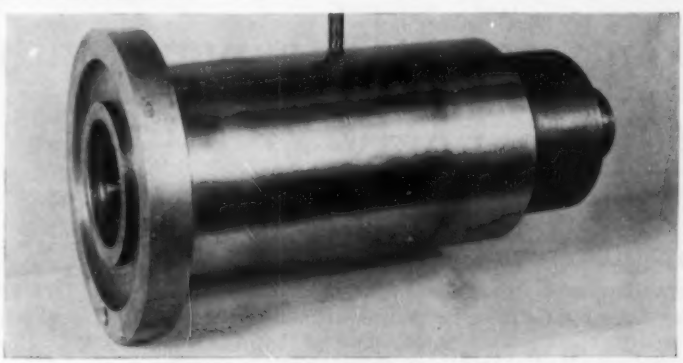

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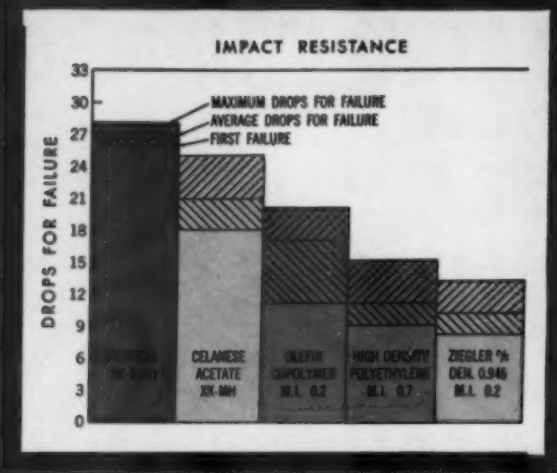

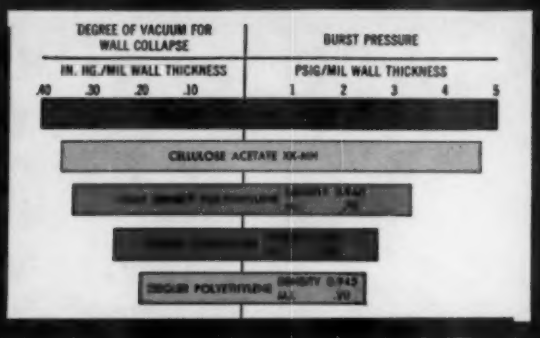

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EDITORIAL

Designing with Plastics Emerging as an Engineering Science

The July issue of *Western Plastics* carried a letter written by Mr. John A. Main, Woodland Hills, Calif., sharply criticizing the plastics industry in general and pointing out that misapplications of plastics have resulted in wide condemnation of products made of plastics or using plastic components. In his letter, Mr. Main writes, "I recently made a major purchase—a portable typewriter. As usual with major items, all makes were investigated impartially. One by one all the American-made machines were eliminated, primarily due to the excess utilization of plastics. On several makes the plastic members were warped, some broken, on brand new machines on the dealers' shelves! The choice narrowed down to one of three machines, all foreign made."

We think that Mr. Main is exaggerating to make a point. Sure, mistakes have been made. But as principles for structural design with plastics have been advanced, there can be seen the emergence of an engineering science.

When compared to the technology of metals, plastics are new. For this reason, there are problems. Lack of knowledge of suitable design parameters, inadequate quality control procedures are just a few of the problems facing the designer. Such problems do not exist for metals for they have long since been solved.

The importance of sound design can be realized when one considers the trend in the plastics industry for end user companies now purchasing from custom processors to set up their own processing operations. To prevent hearing more of the type of complaint printed above, designing with plastics will have to be placed on a sound scientific basis, on a par with metals.

The importance of this area of plastics science and engineering has been recognized by the Society's Technical Volumes Committee with the scheduling and development of a book on Engineering Design for Plastics. Edited by Dr. Eric Baer, the book should improve the quality of existing products, open up new uses which did not seem feasible in the past, and may ultimately be instrumental in reducing costs.

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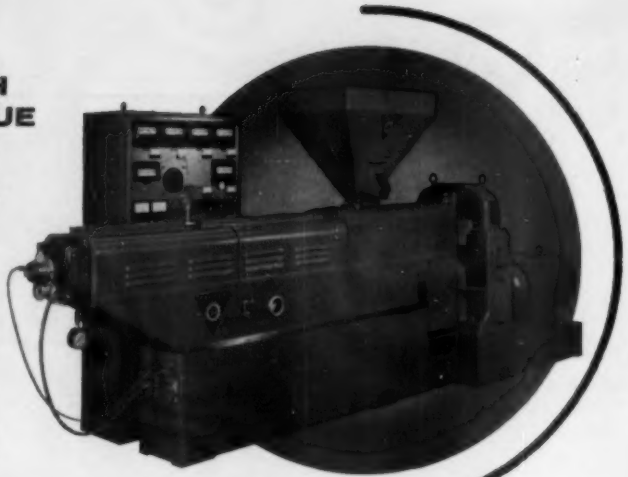

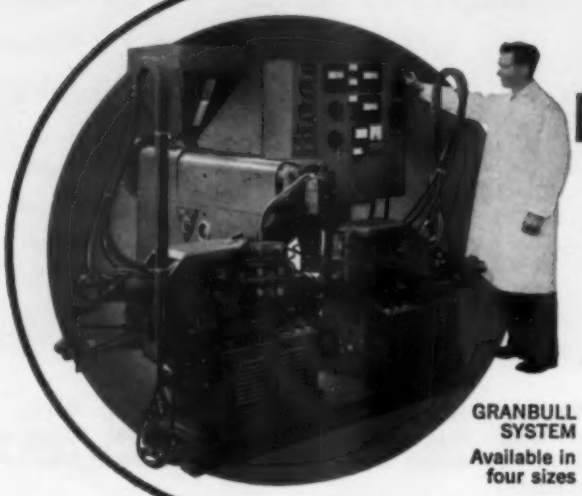

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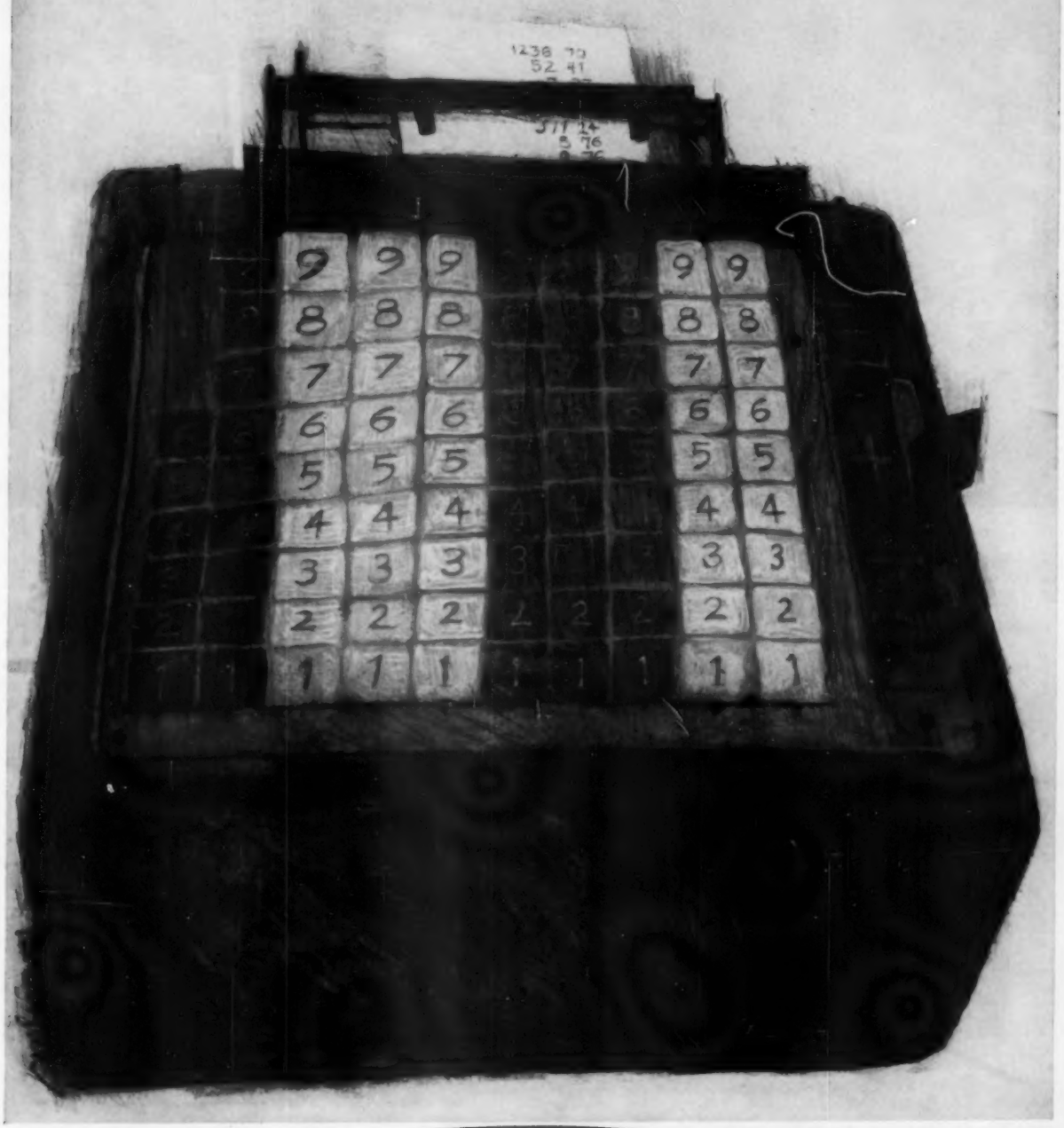

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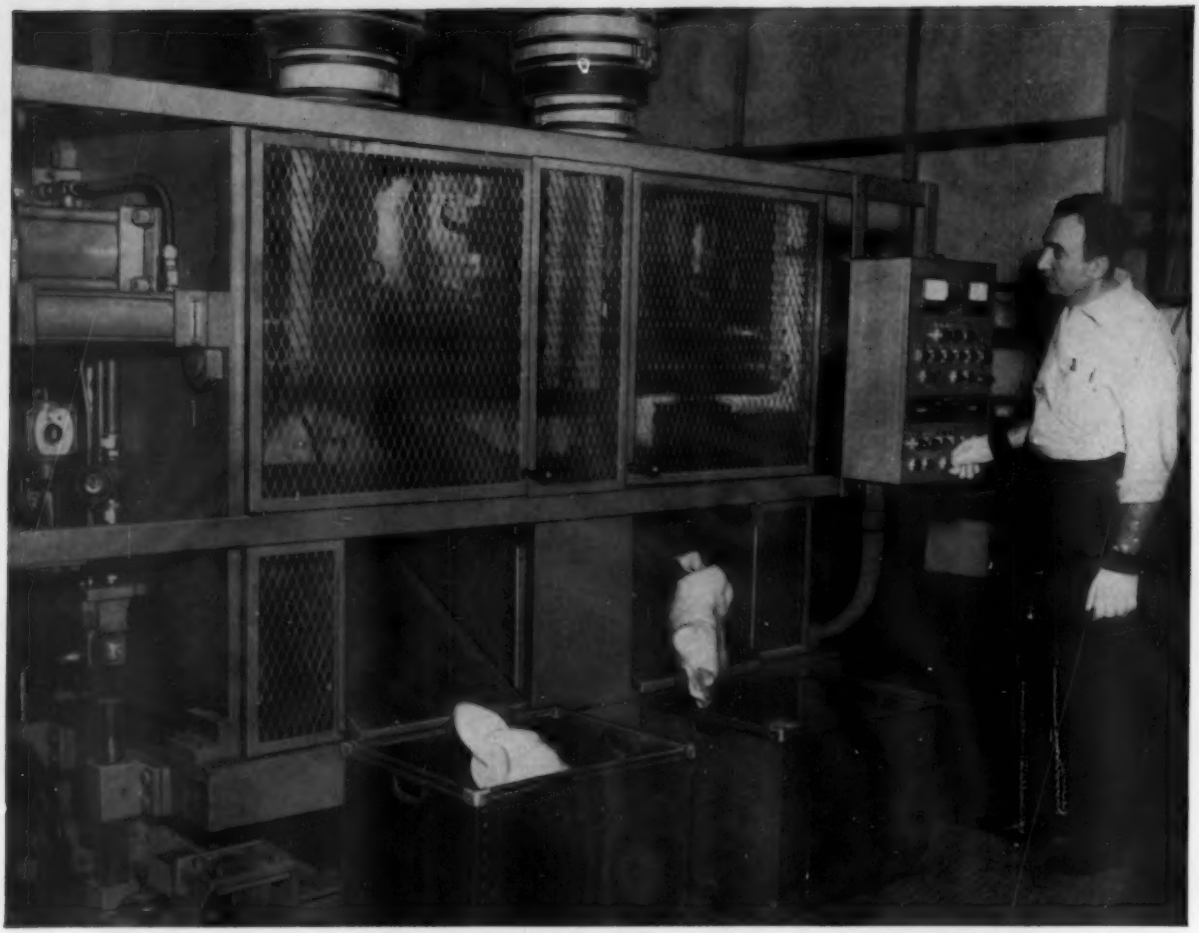

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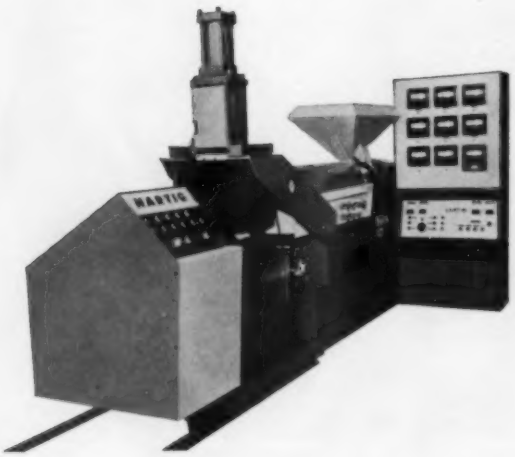

in action at Ideal Toy. Shown above is one of the new Hartig blow molding machines producing doll bodies. Operation is continuous and automatic; output is of high quality and uniform; maintenance is simple. This press can handle parts up to 17-inch diameter, is track-mounted for easy mold changes and extruder maintenance.

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Letters

Dear Sir:

The Editorial in the July 1961 issue of the S.P.E. Journal emphasized standards for plastic materials. For many years now plastics have been used successfully as materials of construction in the chemical industry. With the kaleidoscope of plastics now available to engineers, it is difficult for them to fight their way through the conflicting sales claims, trade-names and types of any given principal plastic. In fact, it is this amount of selection work that causes many a non-plastics engineer to give up and return to traditional materials.

The National Association of Corrosion Engineers, with the blessing of ASA, SPE, SPI and ASTM, is in process of formulating a numbering system to define the basic plastic families and their variants, as well as their basic physical properties on both a short term and a long term test basis. Since most corrosion engineers are basically metallurgists, they have had considerable difficulty in wading through the intricacies of organic chemistry.

As a member of SPE and as secretary of NACE Technical Committee T-5D charged with the above responsibilities I hope that considerable progress will be made in the near future towards completion of this herculean task.

The industry has cooperated to a considerable extent already, but if we want to have plastics accepted as a standard material of construction, manufacturers should release more information on the physics and chemistry of their materials. They can then be assured of a place in the standard numbering system, if their material is indeed unique and basically different from their competitor's.

W. Henderson
Process Development Department
Electric Reduction Co. (Canada)

Dear Sir:

We are a bit embarrassed to find you did not think of us when you printed the item about Material Research on Page 698 of the July issue. They certainly are not the only independent research laboratory and pilot plant facility in the country dealing exclusively with plastics; DeBell & Richardson, Inc. has been doing just that for over fifteen years.

Wesley S. Larson
DeBell & Richardson, Inc.

Editor's Note

Now that you mention it, we can think of a few others, too.

(Continued on page 950)

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MEMBERSHIP CONTEST RULES CLARIFIED

The SPE Membership Committee, under the Chairmanship of Joseph R. Grenier, has recently clarified rules for the 1961 Membership Contest which started on March first and will continue for ten months until the end of this year. In order to reflect a Section's ability both to gain new members and to hold its current membership, the percentage increase this year will be based on differences in the totals of members-in-good-standing and members-in-process on February 28 and December 31.

In the past, the percentage increase has been based upon the total of new applications received during the period of the Contest. This total, however, did not reflect members who did not pay their annual dues. It was thus possible for a Section to win or finish high in the Contest and yet after ten months of membership activity show the same or a fewer number of members at the conclusion than at the start of the Contest. As in previous Contests, student members are not included in Section totals.

While this clarification has not materially affected the standards as of July 31, it will probably have a profound effect on the standards after September 30 when members who have not paid their 1961 dues become members-not-in-good-standing. Remember, your dues must be paid up before your membership counts in the 1961 Contest.

Standings at the halfway point of the Contest are shown at the right:

INTERNATIONAL CONTEST

Standing	*Section*	*% Increase*
	(over 200 members)	
1	Eastern New England	9.1
2	Western New England	5.1
3	Newark	5.0
4	Cleveland	4.4
5	New York	4.1
	(under 200 members)	
1	Pacific Northwest	19.1
2	South Texas	15.6
3	Osaka	10.0
4	Central Indiana	9.2
5	North Texas	8.4

INTER-REGIONAL CONTEST

Region	*Leading Section*	*% Increase*
I	Eastern New England	9.1
II	Buffalo	7.8
III	Baltimore-Washington	6.0
IV	Central Indiana	9.2
V	South Texas	15.6
VI	Upper Midwest	5.4
VII	Pacific Northwest	19.1

LETTERS *(Continued)*

Dear Sir:

We would like to make a few comments on Mr. A. R. Morse's article "Movable Screw Plasticizing Boom?". There are several major inaccuracies and misleading impressions that should be corrected in the interest of presenting an unbiased picture about the screw machine to the American molder.

Mr. Morse makes the statement that movable screw injectors are still relatively unproved. This is not true. Ankerwerk has been building screw machines for over five years and many hundreds of our machines have been in production for years all over the World, including the United States. Many other screw machine producers have had success for several years. Mr. Morse perhaps means that some particular designs of screw machines are still relatively unproved.

He also says cycles are so long that American molders would be driven to distraction. In our experience we are often able to reduce total cycle times by 10% or 20%, even on the common molding materials such styrene, nylon and polyethylene. There is no technical reason why a screw machine should be slower than a plunger machine since screw rotation takes place during the injection, holding pressure, and cooling time, and is, therefore, of no influence on overall cycle. The screw machine can be just as fast as energy input and good construction of the particular machine will allow. As a matter of fact, the proven increase in plasticizing capacity of a screw machine over a plunger machine places the limitation on speed of cycling directly on the cooling ability of the mold. Speaking further on economies of operation; changeover time of colors, and materials is only a fraction of what is normal on plunger machines —the daily amount of rejects is far less —set-up and start times far less and this all is very important to economy of operation in a high labor market.

It is correct that some manufacturers offer many different screw and screw tip designs. On the other hand, Ankerwerk and Krauss-Maffei have developed a screw and tip design that has been proven to handle polyethylene, polypropylene, nylon or styrene equally as well as rigid vinyl or polycarbonate. It is important to remember that the feed and metering problems of a common extruder are not problems in a screw injection machine since the latter is essentially an enclosed system similar to a compounder.

The variability of screw speeds is much less important in screw injection machines than in extruders. The pressure maintained against the screw in its backing compounding motion is the most useful regulation in controlling friction, heat and plasticizing speed.

Mr. Morse states that at 20,000 psi screw injectors give mechanical problems. High injection pressures offer no limitations to screw injection machines since there is enough space for gears and thrust bearings as big as a house if necessary.

The basic patent situation in single reciprocating screw injection machines in the United States is very clear. The only patent existent in this country is patent #2,734,226 issued Feb. 14, 1956, filed by Mr. William Willert and assigned to Frank W. Egan Co. Any machine sold under its license has no confliction because there is no other known patent on the basic screw principle in the United States.

It would be a mistake to call the single reciprocating screw injection machine the answer to all the problems of the American molder, but it would be an even greater mistake to deny him the obvious advantages of the screw in producing a better melt and better casting by indicating that there are so many road blocks in the way of favorable operation of this new development. The American molder is sophisicated enough to be able to listen to the facts and make an intelligent decision.

Dr. H. Frimberger
Jack G. Fuller
Ankerwerk International
Krauss-Maffei International

Dear Sir:

I have enjoyed Messers Hayden and Scharnberg's excellent article "Decorating of Plastics" in the SPE Journal of June 1961. However, I would like to amplify their remarks on Hot-Stamping. There is no universal method which is best for decorating plastics; each offers special advantages and limitations as outlined by Hayden and Scharnberg. But Hot-Stamping offers certain advantages not emphasized by them:—

1.—Because no drying time is necessary, the decorated parts can be handled immediately. This permits decorating at the molding press during the molding cycle, and the use of fully automatic multi-color Hot-Stamping presses operating at high speed.

2.—Special ventilation is not necessary, since Hot-Stamping employs no toxic nor flammable solvents. There are no masks, silk-screens, spray-guns or spray-booths to clean and maintain.

3.—Hot-Stamping foils manufactured by vacuum metallizing yield appearances which can not be achieved by painting or silk-screening.

4.—Maximum durability can be achieved by Hot-Stamping since the formulation of the color coat is not inhibited by the necessity of using resins, or vehicles, which are soluable in solvents (such as alcohols and alaphatic hydrocarbons) which will not attack, or craze, the plastic.

Hot-Stamping consists of using a heated die (either metal or silicone rubber) to melt the color coat into the plastic. This localized heating at times sets up internal strains in thermoplastic plastics, which account to a large measure for the "detrimental effects which come and go without apparent reason" as noted by Hayden and Scharnberg when the Hot-Stamped area is lacquered. Generally speaking, lacquer solvents do not injure the color coat laid down by Hot-Stamping, but may attack the stressed skin of the plastic, thus causing crazing. These strains in the plastic relieve themselves in time at 70°F. (ordinary room temperature) or may be relieved by "normalizing", or annealing, the part for a few hours at 150°F.-180°F.

Richard C. Peter
Peter & Co.

Editor's Note

A copy of this letter was sent to Mr. T. E. Hayden. His reply appears below

Dear Sir:

In general, there are several exceptions which our experience would indicate might need more exploration. Regarding "maximum durability" in a general sense, although there may possibly be a few instances where hot stamp foils would give better durability than paints —for example adhesion upon polyolefin

How MOD-EPOX® liquefies viscous epoxy resins and "liquidates" some of the cost

PERFORMANCE: Reactive MOD-EPOX reduces epoxy resin viscosity as much as 75%, combines *chemically* in the curing to become part of the resin. This means you can use more filler, yet have faster flow, less entrapped air, fewer rejected finished parts. And final properties are actually *improved:*

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FORMULATION:	Control	with MOD-EPOX
MOD-EPOX	—	25
liquid epoxy resin	100	100
diethylenetriamine	12	8
magnesium oxide (fluffy)	—	0.25
FLEXURAL STRENGTH:	psi	psi
original	42,400	48,400
ketone—40 hrs. @ room temp.	42,400	47,700
water—40 hrs. @ 100°C.	29,400	37,600
10% caustic—27 hrs. @ 100°C.	8,500	9,200

Epoxy resins modified with MOD-EPOX for better flow and lower cost show better dimensional stability—lower power factor—equivalent hardness—and higher adhesive strength (*shear bond strength of a standard epoxy adhesive increases more than 50%, steel-to-steel*).

ECONOMY: NOW . . . MOD-EPOX at 36¢/lb.* costs less than any grade or brand of epoxy resin, 50-75% less than most other modifiers . . . AND reduces the curing-agent requirements to about ⅔ of usual amounts.

FACTS: Technical Bulletin PL-313 gives complete performance data—including specific details on how MOD-EPOX can help you make:

- **easy-handling electronic potting compounds.**
- **low-cost auto-body-solder formulations.**
- **high-strength casting and encapsulating compounds.**
- **tenacious adhesives for metals and glass.**

*T/L and C/L, F. O. B. Monsanto, Illinois

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MONSANTO CHEMICAL COMPANY
Organic Chemicals Division
Plasticizer Council, Dept. 4411-V
St. Louis 66, Missouri

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SPE Conference to Feature Plastics in Appliances

A plastics usage with a particularly attractive potential, "Plastics in Major Household Appliances", will be the subject of a Regional Technical Conference sponsored by SPE's Kentuckiana Section on October 25, 1961. To convene in General Electric Company's Monogram Hall in Appliance Park, Louisville, Kentucky, the Conference will cover virtually all aspects of the application of plastics in appliances from raw materials to inspection of finished parts.

The comprehensive technical program is divided into three basic parts—material trends, processing trends and evaluation of plastics products.

Conference luncheon speakers will be W. H. Dennler, General Manager of the Major Appliance Division of General Electric Company, and George W. Martin, immediate Past President of SPE.

The complete technical program is as follows:

PLASTICS IN MAJOR HOUSEHOLD APPLIANCES

October 25, 1961

8:30 a.m.—Registration

9:15 a.m.—Welcome
R. E. Eshenaur, RETEC Chairman
General Electric Co.

Material Trends

Moderator: W. C. Warriner
E. I. du Pont de Nemours & Co.

9:30 a.m.—**Plastics Foams**
F. O. Guenther
General Electric Co.

10:15 a.m.—Panel Discussion—
Advances in Plastics Materials for Major Appliances

Polypropylene
C. W. Williamson
Enjay Chemical Co.

ABS
W. J. Coughlin
Naugatuck Chemical Co.

Rigid Vinyl
J. F. Malone
B. F. Goodrich Chemical Co.

Polyester Premix
S. S. Feuer
Atlas Powder Co.

12:00 noon—Luncheon
Speakers:
W. H. Dennler
General Manager,
Major Appliance Division,
General Electric Co.
George W. Martin
SPE Immediate Past President
Holyoke Plastics Co.

Processing Trends

Moderator: Wendell F. Stewart
Philco Corp.

1:30 p.m.—**Extrusion and Vacuum Forming**
R. C. Alakson
Dow Chemical Co.

1:55 p.m.—**Potential of Blow Molding**
W. O. Bracken
Hercules Powder Co.

2:20 p.m.—**Potential of Screw-Type Injection Molding**
Herbert H. Frimberger
Ankerwerk International

Evaluation of Plastics

Moderator: Gordon M. Kline
U. S. Bureau of Standards

3:00 p.m.—Panel Discussion—
Evaluation of Plastics for Appliances
Moderator: W. E. Brown
Dow Chemical Co.

Dishwashers
E. V. Plock
General Electric Co.

Refrigerators
R. E. Ahlf
Whirlpool Corp.

Clothes Washers
E. W. Albin
General Electric Co.

4:00 p.m.—**Flammability**
L. H. Kline
Underwriters Laboratories, Inc.

4:30 p.m.—Panel Discussion—
Inspection Tests for Finished Parts
Moderator: J. V. Schmitz
General Electric Co.
Speakers:
G. F. Vanderwerp
Hot Point Div., General Electric Co.
Martin Silovich
Kelvinator Div., American Motors Sales Corp.
J. D. Braught
General American Transportation Corp.
Robert R. Dixon
Westinghouse Electric Corp.

Conference registration fees, which include luncheon and a copy of the RETEC preprint book, are as follows:

	SPE Members	Non SPE Members
Advance Registration	$ 8.00	$10.00
On-site Registration	10.00	12.00

Requests for further information and advance registrations should be directed to:

H. G. Cooke, Jr.
RETEC Registration Chairman
c/o Jones Dabney Co.
1481 South 11th St.
Louisville, Kentucky

The Regional Technical Conference has been planned by a Committee of the Kentuckiana Section chaired by Ray E. Eshenaur of General Electric Co. Other major Committee Chairmen include: Program—John V. Schmitz, General Electric Co.; House—John M. Berutich, Haveg Industries Inc.; Treasurer—Frederick O. Guenther, General Electric Co.; Publicity—Milo H. Buzzee, Tube Turns Plastics Inc.; and Printing—Richard H. Rieger, Union Carbide Plastics Co.

surfaces—it has been our experience that quite to the contrary for a general statement, paints offer much more durable surfaces than do hot stamp tapes. The subject might be discussed at rather great length but suffice to say that most manufacturers who have bright foil hot stamped upon radio knobs or control panel fronts require that a top coat of clear paint be applied over the hot stamping to impart added mar and scuff resistance. As to the durability of quality plastic spray paints, the very fact that professional football helmets, etc., are decorated by spray painting should be sufficient to answer most questions as to the durability of air dry coatings. We know of no case where the major decision of whether to decorate an item by hot stamping as opposed to other means was primarily contingent on the durability factor, but rather the economic factors of the best methods of decorating plastics are of prime import.

Unless we are mistaken, hot stamp tapes are made by adhering paint films to a backing such as Mylar and that this paint film is that portion of the tape which is actually deposited upon the plastic. This has to do with whether or not lacquer solvents actually attack the hot stamp foil or the plastic. It is quite true that the paint solvent system must be formulated so that the paint will not attack the plastic, but problems arise when the hot stamp foil coating is of dissimilar resin construction to that of the base plastic upon which it is applied because the solvent system of a particular paint while not etching the plastic may very well etch the hot stamp foil. We have seen this occur time and time again in our laboratory, not only checking hot stamped parts but also the foil itself. It is quite true that the hot stamping operation may cause stresses to be set up in the molded plastic and thus make a part more sensitive to lacquer solvents; however, generally if the hot stamp operation is properly accomplished this is not a problem.

I am very happy to learn of anyone who will take the time from his busy personal schedule to give vital information to those engaged in plastic decorating because this field is expanding so rapidly that the information vital to its continued growth is difficult to obtain.

T. E. Hayden
Product Manager
Bee Chemical Company

Editor's Note

We have since received a copy of another letter sent by Mr. Peter to Mr. Hayden. He indicated that the durability of an organic coating depends upon the formulator. He believes, however, that there is a greater freedom of choice of ingredients when formulating hot-stamping leaves because there is no limitation to vehicles which are soluble in weak solvents. He does agree that there was no disagreement in principle.

How SANTICIZER® 160 speeds processing and cuts costs of nonstaining PVC film and sheeting

PERFORMANCE: No other plasticizer can make film, sheeting, and floor covering so *STAIN-SAFE*—virtually impervious to asphalt, tar, grease, mustard, catsup, coffee, and other stainmakers. SANTICIZER 160 (butyl benzyl phthalate) also imparts toughness, high gloss, *and outstanding tear strength and dimensional stability.*

PROCESSING: Quick-fusing SANTICIZER 160 speeds Banbury mixing, milling, and calendering—*at lower processing temperatures.*

ECONOMY: SANTICIZER 160 is one of the lowest-priced primary plasticizers for vinyls. With its high tolerance for fillers and its high compatibility—*150 PHR for poly(vinyl chloride), 75 PHR for poly(vinyl acetate)*—it offers compounders savings on material, savings on formulation.

"TAILORED" BLENDS: In large-volume applications, when several plasticizers are used together in a fixed ratio for optimum performance, Monsanto can usually *custom blend* them to your specifications . . . to reduce your storage-facility requirements; eliminate mixing error or variation; and reduce inventory requirements, ordering costs, and production expense.

FACTS: Technical Bulletin PL-160 gives complete performance data—including specific details on how SANTICIZER 160 *also* can help you make:

- **lower-cure-temperature plastisols and organosols.**
- **high-gloss, water-resistant lacquers.**
- **economical vinyl chloride-vinyl acetate emulsions.**

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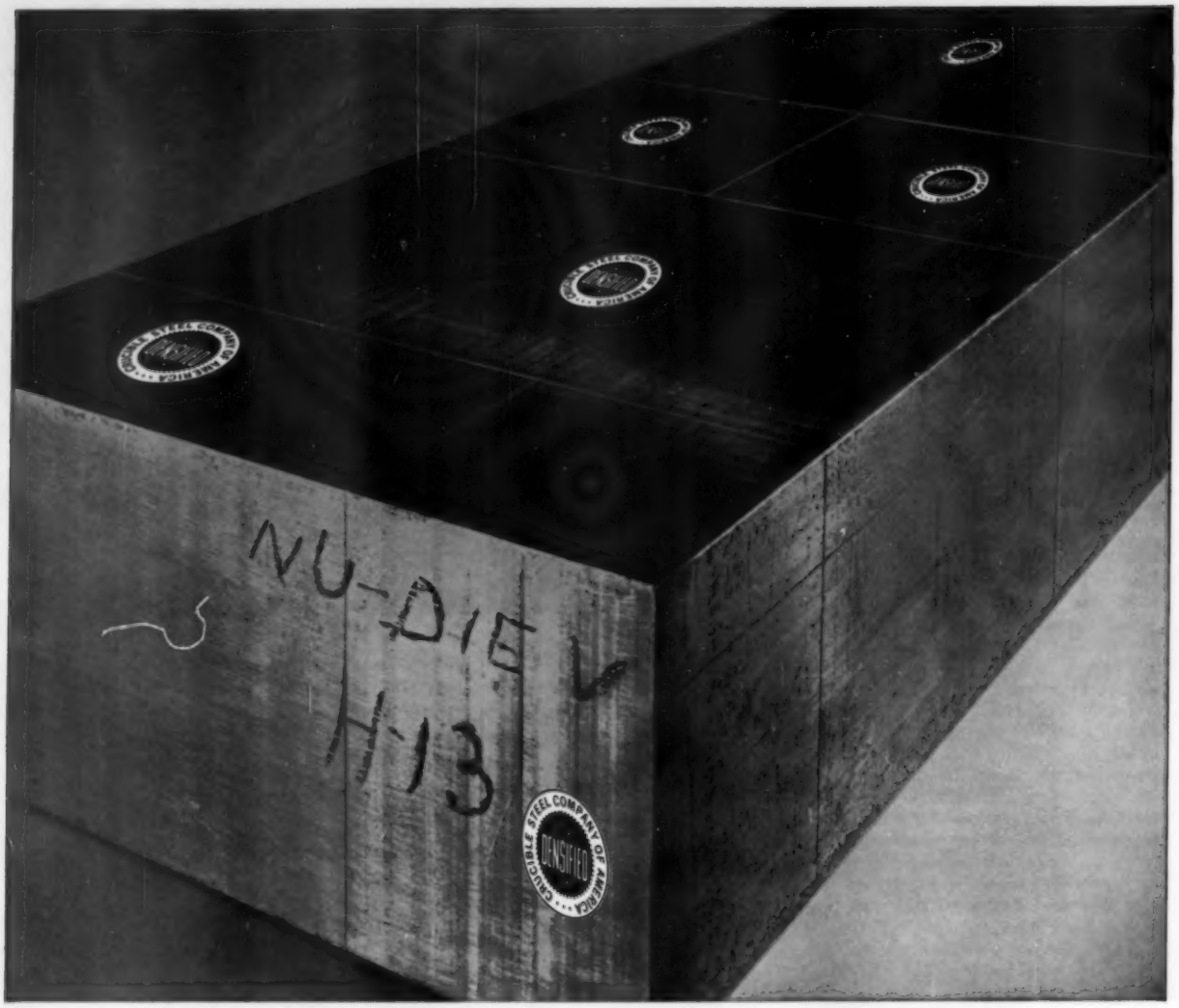

every surface—die quality . . .

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A new Crucible process—DENSIFYING—sets NU-DIE V apart from other H13 steels. *Densifying* benefits you in four major ways: *1.* It permits you to use larger sections with greater assurance of sound centers. *2.* It enables you to produce dies with even better finishes. *3.* It makes your dies less susceptible to washing and cracking. *4.* It also speeds deliveries of your die blocks because NU-DIE V now eliminates the need to specify individual forgings.

The DENSIFYING process, developed by Crucible, involves more than the normal consideration of steel analyses and amount of reduction. It includes careful appraisals of ingot size and shape, processing temperature control, and special methods of reduction. Only Crucible successfully combines all these techniques to produce this more uniformly *dense* Type H13 steel.

For more information on DENSIFIED NU-DIE V or CSM 2 die steels, call your local Crucible steel center.

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CRUCIBLE STEEL COMPANY OF AMERICA

SPE JOURNAL NEWSLETTER

reading time
1 minute

FCC Rules on Electronic Equipment

Electronic equipment used in industrial, scientific and medical fields such as the type employed for pre-heating and sealing of plastics can interfere with radio navigation and safety services. FCC, reportedly, will order interfering equipment out of use. Certification, by contacting the manufacturer or a qualified engineer, is necessary. The SPI Radio Frequency Interference Committee (250 Park Ave., N. Y. C.) will help users meet specifications.

Semiconducting Polymers

Princeton University research indicates that conventional band theory does not explain semiconductor effects in highly conjugated polymers. High degree of conjugation, however, is considered a source of electron carriers and a mode for their transport. Polymeric synthesis should allow for economical production of semiconductors with pre-chosen properties.

Nylon Casting Process

Low cost casting of massive nylon shapes has been announced by Polymer Corp. Similar in technique to the casting of metal, nylon caprolactum monomer is converted directly to the finished shape by strict temperature control, eliminating the necessity of polymerizing and casting separately. Savings are in raw material because of lower monomer cost; in lower tooling costs, because of lower pressures. Substituted for lower priced plastics and certain metals, castings will not compete with injection molded small parts.

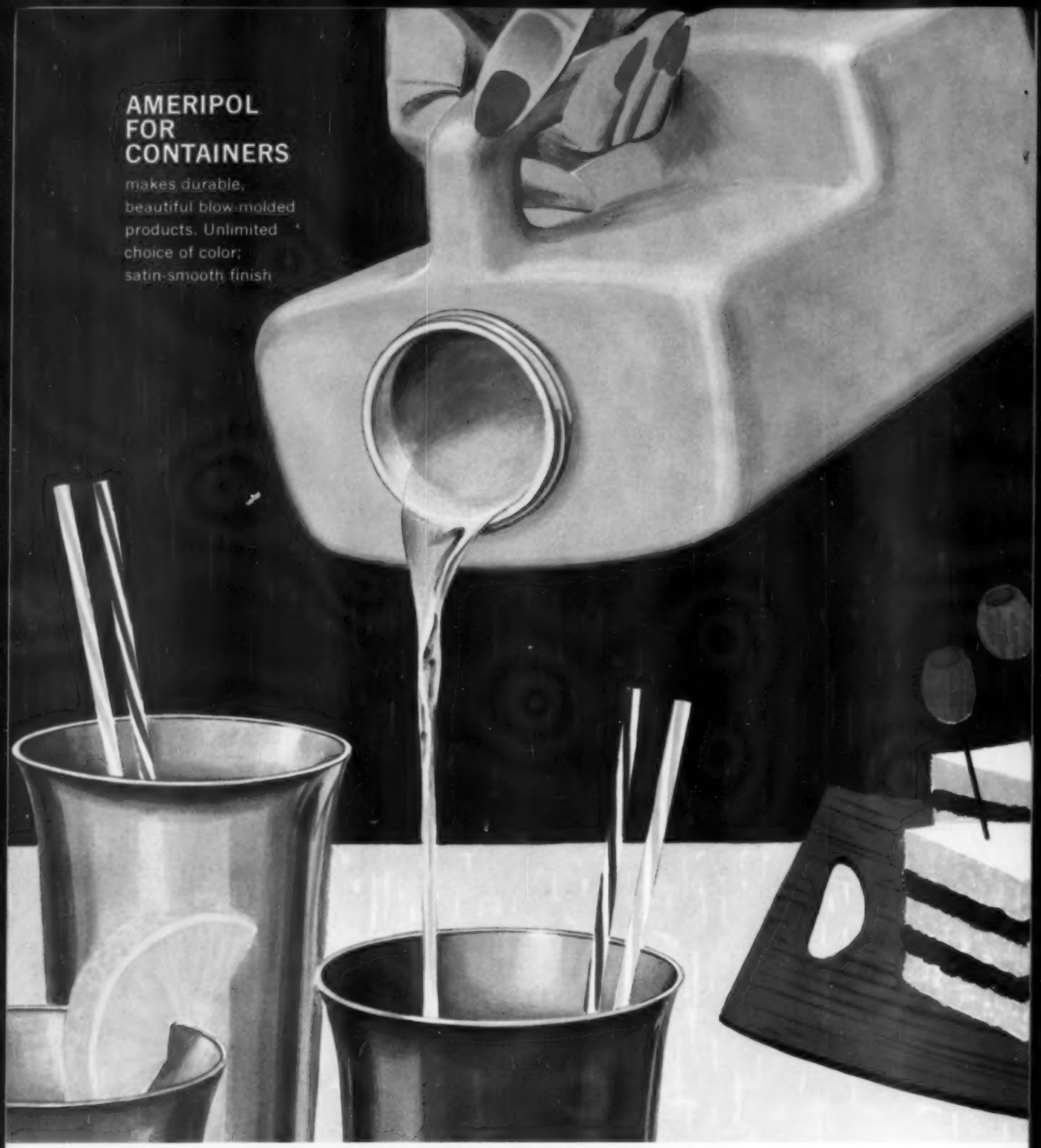
Plastics in Building

In 1960, 972 million pounds of plastic materials were used for construction purposes, in addition to 428 million pounds of alkyds, rosins and cuomarene-indene and petroleum polymers. Total represents 24% of plastics production, as reported by Monsanto. All vinyls, with 305 pounds consumed, represented the greatest single amount.

Liquid Permeation in Plastics

Permeability of liquids in polyethylene depends upon the size, shape and polarity of the permeating molecule. It has been found that this property can be predicted if chemical composition of the permeant is known. October SPE TRANSACTIONS reports on permeability prediction.

new technical ideas • trends • industry news



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excellent impact strength and stress-crack resistance make a superior plastic pipe — yet easy to extrude on standard equipment

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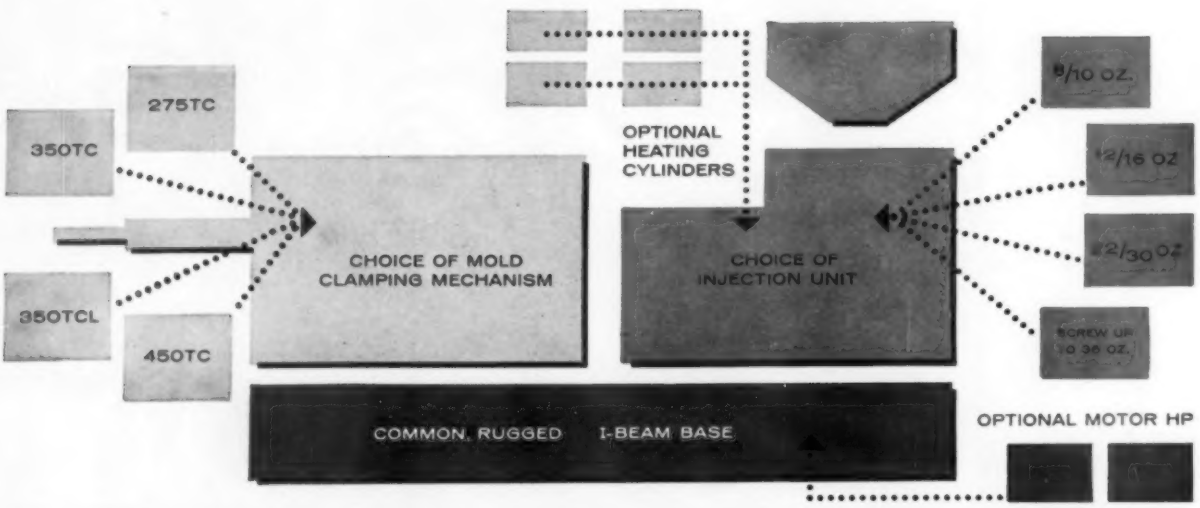

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In addition to standard plunger-type injection ends, REED now offers (1) a reciprocating screw injection unit, or (2) a two-stage injection system. These units can be specified with any REED "Building Block" machine. The REED reciprocating screw gives you good color blending, faster material and color changes, more effective injection pressures and stronger molded parts.

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it's all one piece!

Opening and closing this one-piece carrying case demonstrates the remarkable "hinge" property of TENITE POLYPROPYLENE

Flexed a million times in one continuous laboratory test, a molded specimen of Tenite Polypropylene—the Eastman plastic with the "built-in hinge"—showed never a crack. That's why this case can have its base, cover, and handle molded as a unit, with obvious savings in design, fabrication, and assembly.

Made for a child's typewriter, the case is well able to take slam-bang treatment that will come its way. The high abrasion resistance demonstrated in this use gives long life to the beauty of many products made from Tenite Polypropylene, and also suggests its use for gears, bearings, and similar hard-working parts.

In addition to being injection molded, Tenite Polypropylene can be extruded into film, sheeting, and monofilaments, and in special formulations is adaptable to blow molding, where its exceptional strength permits thin walls. The film is sparkling clear, heat-sealable, printable, and an effective moisture barrier—important features in packaging. Rigid sheet is readily thermoformed on standard equipment into large-scale sections or skin packaging.

As extruded wire covering, Tenite Polypropylene exhibits excellent electrical and thermal properties. And formulations combining weatherability, low-temperature flexibility, and high tensile strength may be used to produce monofilaments that are ideal for such applications as webbing for outdoor furniture.

With the lightest weight of any solid plastic, Tenite Polypropylene gives the greatest product yield per pound. As for colors, thousands of vibrant hues are available in Tenite Polypropylene—or in color concentrates for mixing with uncolored plastic to produce the desired color when molded or extruded. Eastman experience in coloring plastics extends over 25 years, with additional background in color photography and textile dyes. In applying this plastic to your product ideas, you can call on the aid of Eastman's technical representatives and its extensive laboratory facilities. For information on Tenite Polypropylene or any other plastics in the Tenite family—butyrate, acetate, propionate, or polyethylene—write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

Carrying case molded by manufacturer of the "Tom Thumb" typewriter, Western Stamping Company, Jackson, Michigan.

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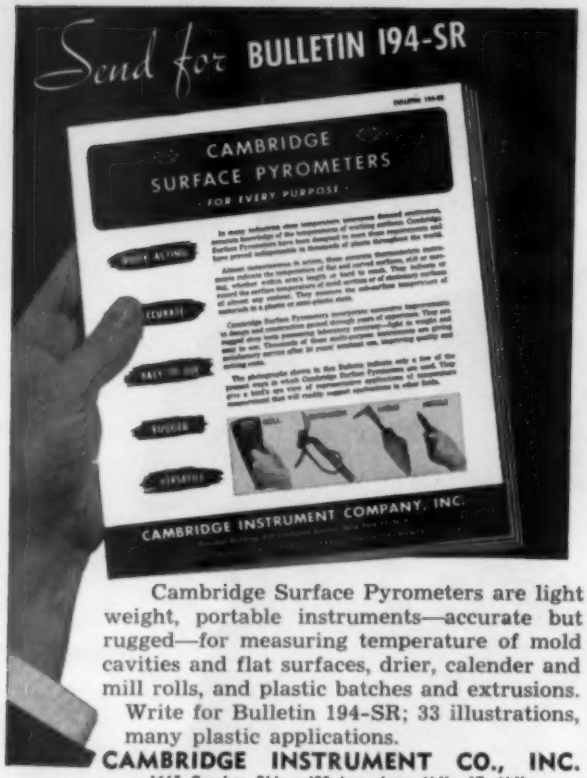
POLYPROPYLENE

an Eastman plastic



Cambridge Surface Pyrometers are light weight, portable instruments—accurate but rugged—for measuring temperature of mold cavities and flat surfaces, drier, calender and mill rolls, and plastic batches and extrusions. Write for Bulletin 194-SR; 33 illustrations, many plastic applications.

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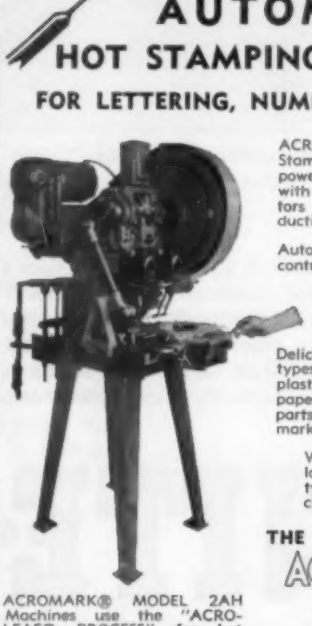

ACROMARK MODEL 2AH Hot Stamping Machines are fast powerful and efficient. Equipped with automatic feeds and ejectors they satisfy most high production line requirements.

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International Plastics Standards . . .

an inter-society relations report

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The International Standards Organization (ISO) is a world forum and clearing house for development of internationally recognized standard test procedures and specifications. It was organized in 1946 and maintains headquarters in Geneva, Switzerland. Present membership consists of the national standards bodies of 44 participating countries. The U.S.A. member is the American Standards Association (ASA).

The ISO accomplishes its objectives through activities of about 100 technical committees of which Technical Committee 61, usually designated ISO/TC-61, is concerned with plastics. Present committee membership consists of 21 participating and 14 observer countries. The United States currently has the International Secretariat. The American Standards Association has delegated responsibility for U.S.A. activity on behalf of ISO/TC-61 to the American Society for Testing Materials (ASTM) which has organized the U.S.A. National Committee for TC-61 (USANC). For administrative purposes, USANC is Subcommittee XXI of Committee D-20. At present, ASA, ASTM, Manufacturing Chemists Association (MCA), SPE and SPI are represented.

The international body meets once a year, usually in the Fall and usually in a different country each year. At the October 1960 meeting in Prague, attended by 110 delegates from 15 countries, there were twelve representatives from the U.S.A. Thus far, two meetings have been held in the U.S.A. (1951 and 1958). The U.S.A. committee meets three times a year in addition. In the intervening time, business is conducted by mail.

The accomplishments of ISO/TC-61 to date consist of 23 published standards (officially called "Recommendations"), covering a variety of test methods, and, in the case of ISO/R194-1961, a list of 905 equivalent terms in English, French and Russian. Corresponding terms in German, Italian and other languages will be added later in appendices. Copies of the complete list of these official "Recommendations" are available from the American Standards Association, 10 East 40th St., New York 16, N.Y.

Whether making plastics or plastics raw materials directed toward foreign markets, or buying these materials to fabricate into articles for sale abroad, protection from unfair foreign competition is needed. Quality products should not be in competition with inferior ones because there are no universally recognized criteria of quality. ICO recommendations now provide part of the needed protection in the form of internationally agreed upon test methods, for the establishment of mutually recognized levels of quality.

Through the work of USANC to date, several of the items already accepted or under consideration are based on standard American procedures now familiar and in use. In some other cases, the ISO proposals include improvements over our corresponding techniques.

Editor's Note: *John B. Howard and Norman A. Skow are two of SPE's three liaison representatives to the International Standards Organization. The third is Douglas A. Mason, who represents SPE's Canadian Sections. All are members of the SPE Inter-Society Relations Committee, responsible, under Chairman Richard B. Bishop.*

North Texas Section To Sponsor Packaging Retec and Exhibition

The first SPE Southwestern Packaging Exhibition will be held in Dallas, November 1-3, 1961, at the Sheraton-Dallas Hotel. It will be held in conjunction with the North Texas Section Regional Technical Conference on "Plastics in Packaging".

Peter W. Kent, of Monsanto Chemical Co., Dallas, is general Chairman of both the Exhibition and the Regional Technical Conference.

At the RETEC, outstanding speakers in plastics package design, engineering, processes and materials will be featured in the program. A complete display of the latest packaging technology will be staged by leading manufacturers in the packaging fields, with special emphasis on new developments and new materials.

The Exhibition will be sponsored by the North Texas Section of SPE in cooperation with the Southwestern Chapter of the Society of Packaging & Handling Engineers.

Full information with regard to registration for the technical conference and display space can be obtained by writing to Peter W. Kent, General Chairman, Southwestern Packaging Exhibition, P. O. Box 13086, Dallas 20, Texas.

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TENITE DEVELOPMENT LABORATORY DOINGS AND FINDINGS

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It has been found that some polypropylene—not all, just some—is subject to oxidation and resulting degradation in applications involving contact with copper or copper alloys. (Coated copper wire and ballpoint pens with ink cartridges made of a copper alloy are typical examples.) A simple and easy-to-make test identifies the culprit in the line-up. Just melt some polypropylene pellets in a copper dish and let it cool to room temperature. If oxidation occurs, the plastic develops a brown discoloration. Perform this test on appropriate Tenite Polypropylene formulations and you'll find you get practically no discoloration. Here's the clean result:

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Vacuum Forming Polypropylene

Here is a helpful hint for vacuum forming polypropylene plastic sheet. Screen both upper and lower heaters with 8-gauge stainless steel mesh. This will help distribute the heat evenly and eliminate "hot spots" which sometimes cause sheet to rupture when vacuum is applied. A sheet 100 mils thick reaches forming temperature in about 30 seconds when held between two mesh-covered heaters at 1075°F. For a tough and durable vacuum-formed product, use sheet extruded from a high-impact formulation of Tenite Polypropylene.

Unsolicited Testimonial

Recently, on a lonely park lane, a company installed an experimental street light globe fabricated of Tenite Butyrate plastic. The lane, as it turned out, was a popular rendezvous for young lovers. One morning the globe was found badly battered.

Evidence indicated that someone had tried to put out the light with a stone. Failing in this, the person climbed the pole, threw the globe to the ground, and smashed the light. The globe, however, was still unbroken, so the vandal put it against the curb and ran over it with his car. He was apparently impressed by the strength of the plastic material because he wrote a little note which he stuck in the battered globe before putting it back on the pole. The somewhat colorful language in the note prevents our quoting it directly, but the gist of it was that to break one of these new plastic globes was just too much trouble.

The resistance of Tenite Butyrate to shock is so great that even when globes are pierced by BB shot and small bullets, they remain in a serviceable condition. For this reason, New York City's orange-colored light globes are now being made of Tenite Butyrate. These are the globes that are mounted atop a pole to indicate the location of fire-alarm boxes.

Special outdoor formulations of Tenite Butyrate combine weather resistance, rigidity, and excellent light-transmission and diffusion properties with an Izod Impact Strength as high as 2.0 ft. lb./in. of notch in an MH flow. This combination is unexcelled among thermoplastics for serviceability in such uses as street-light globes, outdoor signs, and lenses for automobile tajllights, railway signals, and traffic-control lights, to name but a few. For more information about Tenite Butyrate for outdoor applications, contact your nearest Tenite representative or EASTMAN CHEMICAL PRODUCTS, INC., *Plastics Division,* KINGSPORT, TENNESSEE.

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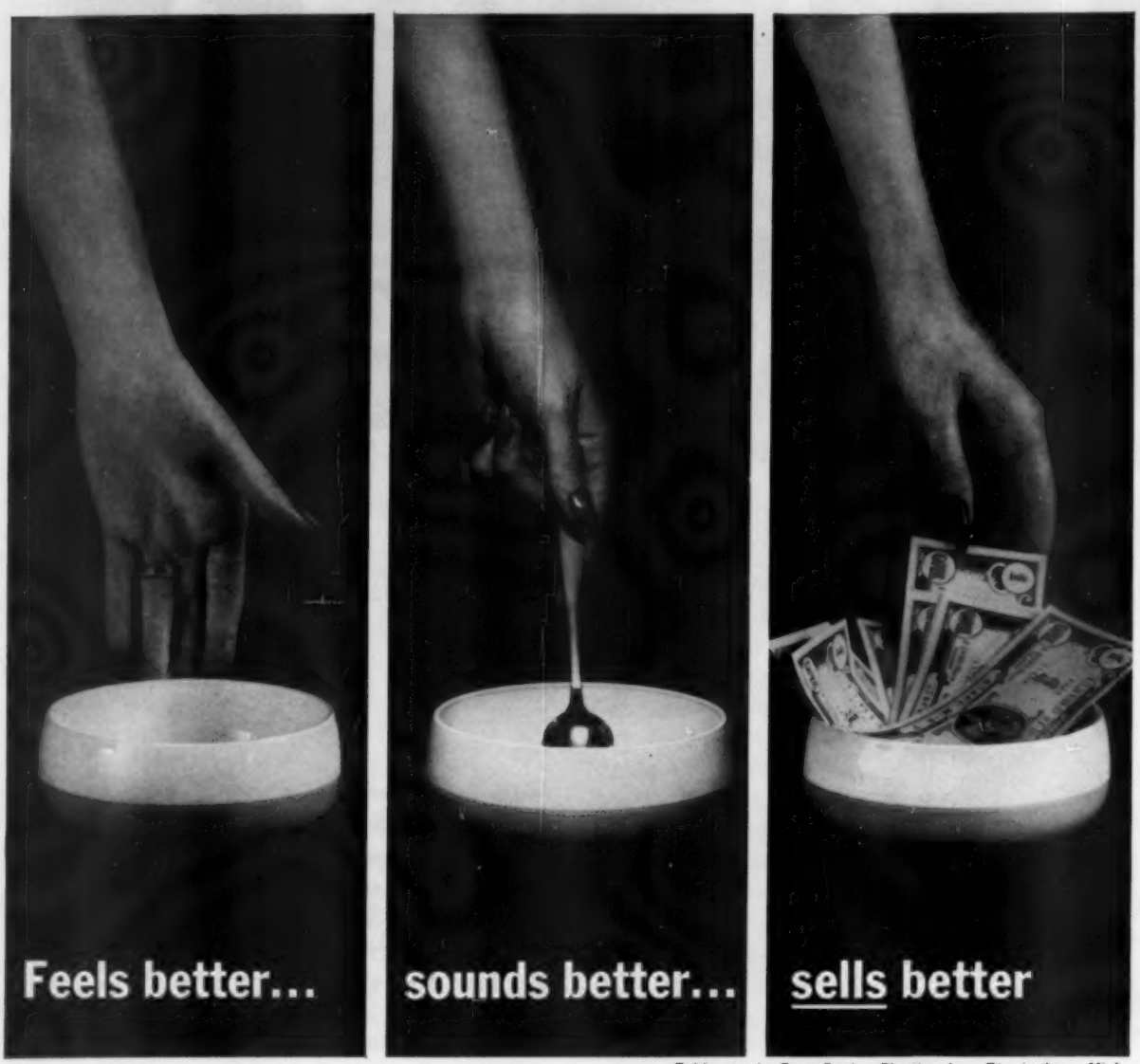

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SPECIAL FEATURE

Rigid Polyurethane Foams and Fire-Retardancy

Louis I. Naturman

Technical Editor

One of the disadvantages in the applications of rigid polyurethane foams has been the lack of a good fire-retardant system in which the properties are not degraded. Most of the ordinary additives lend fire-retardant properties but are detrimental to foam properties. This SPE Journal Feature investigates polyurethane foams and the new built-in type additives

The interest in fire-retardant urethane foams is a reflection of the interest displayed by the chemical industry in the potential of rigid foams in general. Fire-retardancy is believed to be the critical point about which the volume usage of foam for marine, construction and appliance use will be based. Because of the attractive properties of urethane foams, great efforts are being expended to introduce flame retardancy into a rigid polyurethane foam system.

Markets

It was estimated that about 12 million pounds of rigid foam were consumed in 1960. A respectable overall growth rate is expected resulting in total sales of 115 million pounds by 1965. The estimated industry break-down of end uses for rigid foams for 1961 and 1965 are described in *Table 1*.

The 115 million pound rigid foam estimate for 1965 is nominal.* If use of foam catches on (especially in the construction industry), consumption should be well above this figure. If however, the construction industry does not accept this new building material, consumption could fall short of this figure.

The growth in consumption of polyurethane foams will be based upon the following factors:

1. Variable formulation makes it possible to tailor composition for a specific end use. They are amenable to the typical methods of producing foam, whether it be slab stock, molding or spraying. Use of foam for insulation can save on-site labor costs.
2. Urethane foams have a low k factor (refer *Table 2*) when compared to other foamed materials. They are especially efficient for low temperature applications.
3. Urethane materials are thermosetting; therefore they will not soften at higher temperatures but burn, degrade or char ordinarily. Fire retardant foams have the added advantage of supplying a fire barrier.

Growth will be dependent upon how foams will be accepted, notwithstanding their desirable properties.

Acceptance of Foam

The acceptance of polyurethane foams for building and other applications should depend upon:

1. Comparative costs of various competitive materials, a factor dependant on the properties required for a particular application. In con-

Table 1. Rigid Foam Consumption

	Millions of Pounds 1961	Millions of Pounds 1965
Appliances and refrigerators	4	30
Industrial and commercial refrigeration (including transportation)	4	15
Marine	2	20
Construction	2	50
Total	12	115

Source: Composite Industry Figures

* Some estimates give the eventual total potential urethane foam market as one billion pounds, with 800 million to residential housing and 100 million to commercial.

You can have a copy of this up-to-date survey of what is happening in the field of built-in fire-retardant polyurethane foams. Write, Editor, SPE Journal, 65 Prospect St., Stamford, Conn.

struction, for example, it is important to compare the total installed cost of a wall section, labor included, also considering, desired acoustical, insulation, coating and structural properties. With price reductions in urethane foam, there should be volume use in this area as well as in appliances. Urethane foam prices fell from $2.00/lb to $0.45-0.80; styrene, from $1.00/lb to $0.15. It was predicted that (5) the cost of resin and polyisocyanate would have to drop to $0.25 and $0.50, respectively, before urethane foam could attract a serious proportion of the appliance field; low price of fibrous insulation is currently $0.30/cu. ft.

2. Resistance to change by architects, builders and consumers is an important consideration as long as the price remains equal to or greater than competing materials. Effective promotion and raw material cost reduction would be needed.

3. Acceptance by building and electrical codes, underwriters and insurance companies. With the vast number of local, area and regional codes, along with underwriting and insurance complexities, this would be one of the more complicated problems. Today, urethane foams are used for buildings where restrictions are lighter. Many of the safety tests are not specifically designed for plastics material, nor do they measure the efficacy of material for insulating or construction, but they are the accepted today. Fire-retardant materials stand a better chance, with acceptance paving the way for increased consumption. The big consideration, code restriction, is most stringent in New York and Chicago.

Foams in Buildings

In industry, most foam thus far has been used for curtain walls, roof insulation and some spray applications.

Illustrating the advantages of polyurethane foam in building, Standard Clay Products Research Foundation has developed some comparative costs, representing the cost differences in insulating a cavity wall with various types of fillers. The ordinary urethane foam having no air supply within the cavity, did not burn, but suffered distortion at 250° and softening at 350°. (Tests made at Ohio State University, ASTM E119-55T procedure). The foam no longer functioned as an insulator but not due to actual burning. With the foam in contact with air, however, a direct flame will cause the material to burn. When the material costs are compared (*Table 2*) the high insulating qualities of polyurethane are advantageous, when extrapolated to a sufficient number of years. (Costs based on 50 year period, average American Society of Heating Engineers (ASHE), temperatures assuming use of non-fire extinguishing foams.) These tests were made to determine the fire resistant qualities of a urethane wall for insulation and structural purposes, over 1000°F, where a masonry section separated the foam. Fire-retardancy here, is not as important as with inside walls where flame spread should be limited. If the premium for fire-retardancy is not great, however, a fire-retardant foam would probably be used in the masonry wall.

Fire-Retardancy

Because of the organic nature of plastic materials potential fire hazard is inherent to the nature of the material. Rate of flame spread, resistance to heat and internal heat generation are important fire hazards. In order to inhibit flammability of these materials various elements can be introduced into the system. In general, compounds containing various combinations of either phosphorus, halogen, nitrogen or antimony oxide are used. In the case of polyurethane foams the following type additives have been used in most formulations: Tris(chloroethyl)phosphate, tris 2,3-(dibromopropyl) phosphate,* diammonium phosphate, various phosphonates and antimony oxide. These additives acting as fillers or plasticizers will lend retardancy at the expense of the other properties. Dilution will weaken the strength of the foam and produce an inferior product. Heat distortion, hydrolytic stability, water absorption, compressive strength and resilience properties suffer in various degrees with these additives. Discoloration is also a harmful side effect. Ideally, flame retardants should be permanent, stable and not cause impairment of any of the foam properties.

Much of the future success of polyurethane foams is largely based on a volume utilization of plastic foam for building and appliances. This end use item is in turn dependent upon the degree of fire retardancy or self-extinguishing properties of the material. If the material will deteriorate with the addition of the above mentioned compounds it will be impossible for it to attain any degree of success in this area. Therefore fire-retardancy is desirable along with attractive and stable physical properties. To achieve this end researchers began investigating by introducing the flame retarding elements directly into the back bone polymer. On this basis it was assumed that there would be no dilution, migration, settling, dissolving or attacking of the polymer and that properties would remain intact. Research has been conducted in this area for many years with the initial interest in urethanes being with flexible foams for the most part.

It is not always easy to introduce the material into the molecular structure. Most of the approaches have been to try to introduce halogens or phosphorus into the system. The material which is developed commercially is generally associated with that particular company's past experience. Hooker's Hetrofoam based on HET acid and Virginia Carolina's phosphorus based Vircol 82 are two typical examples.

* Halogenated phosphate esters are efficient plasticizers.

Table 2. Insulation costs of filling a cavity wall

Filling	k Factor	Estimated Initial Cost	Initial Cost & Heating Expense	Initial Cost & Heating + Cooling
Uninsulated			$1.00	$1.65
2½" Expanded Mica (dry)	0.30-0.455	$.10	.48	.73
2½" Glass Fiber	0.30	.15	.47	.68
1½"* Urethane Foam**	0.11-0.16	.22	.48	.64
2" Urethane Foam	0.11-0.16	.29	.49	.62
2½" Urethane Foam	0.11-0.16	.36	.52	.63

Source: E. I. du Pont de Nemours and Company and Structural Day Products Research Foundation.

* Note—the 1½ inch urethane foam should best be compared with 2½ inch glass fiber. Because the k factor of glass fiber is about double that of urethane, for like insulating properties the thickness of glass fiber should therefore be doubled.

** This is CCl_3F blown foam. CO_2 blown urethane foam has a k factor of about 0.25.

The advantages of using a fire-retardant foam are illustrated poignantly in *Figures 1 and 2*, where high temperature stability and resistance to fire and flame impingement are depicted. Fire retardant foams generally have properties similar to non-retardant polyester and polyether-based foams of density about 2pcf. In addition they are non-burning according to ASTM test D-1692-59T.

Hetrofoam

The Durez Division of the Hooker Chemical Corporation has specialized in fire-retardant polymers derived from (1,4,5,6,7,7,-hexachlorobicyclo (2.2.1) -5-heptene-2, 3-dicarboxylic acid, known as HET[1] or chlorendic acid. Containing 54.7% by weight of stable chlorine, it is the basis for Hooker's fire-retardant Hetron polyester resins and Hetrofoam[1] polyurethanes.

The experience gained in formulating, manufacturing, and selling Hetron polyester resins was used to develop Hetrofoam, which has good physical properties with non-fugitive fire resistance.

Hetrofoam systems based on a reactive hydroxyl polyol have been designed to utilize both the one-shot and semi-prepolymer techniques in conventional equipment. Hetrofoam 250 is representative of a fire-retardant one-shot system and is being recommended for slab-stock operations and for applications requiring a high rise in thin sections; 190/191 is a fire-retardant semi-prepolymer system, used for slab-stock and structural purposes where high densities are required.

The price of a Hooker system will vary with the formulation, but it is competitive with other systems. Some of their systems are now being sold in the $0.60/pound range. If the advantages of a polyester system are desired, it will be advantageous to use this system and achieve the fire-retardant bonus. These prices are based on today's quoted prices (refer to *Table 3*).

A chlorinated built-in fire-retardant foam contains a large proportion of HET acid. Therefore, the economic wisdom of purchasing HET acid on the open market for the purpose of manufacturing a fire-retardant resin is doubtful.

Vircol-82

Virginia-Carolina, whose initial interests lay with fertilizers and phosphorus have branched into the organic field. They have been investigating fire-retardancy in urethane foams for the past five years. Virginia-Carolina originally started working on low temperature properties and flame retardancy on flexible foams, but the difficulty of incorporating fire-retardant properties into a foam economically without causing a significant loss of properties, coupled with a more real need for this property in rigids caused research to be concentrated into this rigid area. They have used phosphorus as a basis for introducing self-extinguishing characteristics into a foam system. Working initially with polyesters, they have now concentrated on polyethers. Vircol-82 is a polyol which contains about 11% phosphorus and has a hydroxyl number of 212* and a functionality of 2. At this point it is recommended by the company to react this Vircol-82 at prepolymer stages. The formulation developed is termed VC-557. In the near future they are expected to introduce a one-shot formulation onto the market.

Concentrations of about 5-20% of Vircol-82 may be used depending on the degree of fire-retardancy required. At the date of writing the material sells for $0.70 per pound in lots of 40 drums f.o.b. Charleston, North Carolina. There is some speculation that this price will be reduced with the increase in volume. Most of Virginia-Carolina's markets are directed towards the polyether market. Assuming a one-shot system and cost of $0.28 for the polyether resin a foam system containing 38% TDI, 43% polyether and 15% fluorocarbon will cost about $0.45 per pound. A 20% incorporation of Vircol-82 will bring the price up to $0.53 per pound, a significant increase of about 17%. A 10% addition will bring the price to $0.49. (Refer to *Table 3.*) All prices depend upon the particular formulation involved and raw material prices. Prepolymer systems should be about twenty cents higher.

* 1-3% of phosphorus in the foam can generally lend sufficient fire-retardancy.

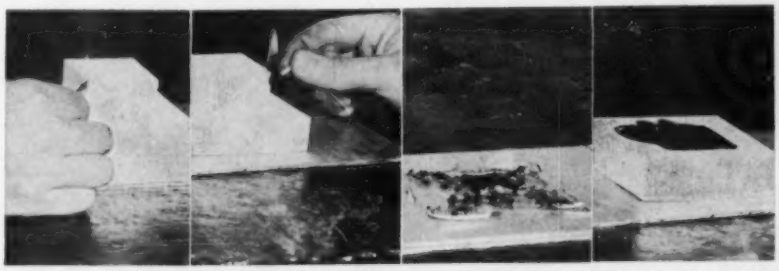

Figure 1. This series depicts self-extinguishing properties. On the left side a block of conventional foam is placed on top of a conventional polyether foam. On the right, a block of conventional foam on a self-extinguishing polyether foam. They are both lit simultaneously.

Courtesy of Virginia-Carolina Chemical Corporation.

When a flame is applied to either foam specimen, no burning occurs, however, the material chars. If a hot

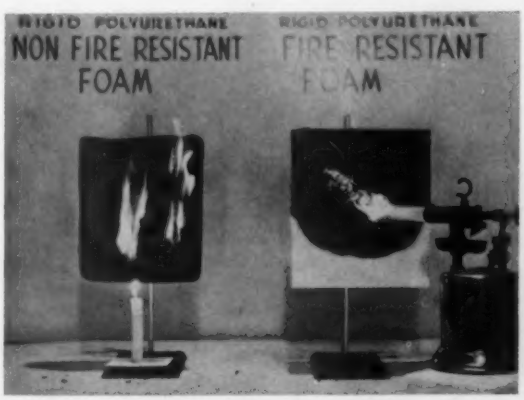

Figure 2. A blow torch played upon non-fire resistant foam on left and fire-resistant foam on right. The back of the specimen on the right can be touched by hand during the impingement of the blow torch flame.

Courtesy of Hooker Chemical Corporation.

[1] Trademark, Hooker Chemical Corporation

Table 3. Comparative Foam Costs (one-shot)[1]

	Cents per Lb.
Ordinary Polyether System[2] (38% TDI, 43% Resin, 15% CCl_3F)	$.45
20%[3] Vircol-82	$.53
10% Vircol-82	$.49
Ordinary Polyester System (32% TDI, 53% Resin, 10% CCl_3F)	$.53

[1] One shot systems were used for comparison purposes. To date there is no commercial one-shot VC system. Raw material costs are generally comparable for prepolymer systems, but a premium of about $0.20 is paid for handling, etc. System costs were estimated using the following prices: TDI—$0.70/lb., CCl_3F—$0.20/lb., surfactants. Catalysts assumed constant at $0.03/lb.
[2] Polyester assumed at 28¢/lb.
[3] 23% ordinary polyether and 20% V-C 82.
[4] Polyester resin assumed to be 45¢/lb. and

blow-torch flame is played directly on the material for a sufficiently long period of time the flame will work through the specimen.

Other Companies

Most of the other companies in the resin business are not disclosing where they stand with regards to any new inherent flame retardant systems they may have developed. Most of the fire-retardant foams should be based on phosphorus, halogen or antimony. The type of formulation used is also important to the eventual foam properties however. Some of the companies displaying an active interest in this situation are:**

1. Wyandotte Chemical Co. has been investigating the situation from the halogen and phosphorus approach for polyethers. Interest has been indicated for phosphorus.

2. Dow Chemical Co. has shown extreme interest in the problem as a result of their experience with polyglycols and styrofoam and have now available some built-in fire-retardant board stock available in experimental quantities. They have worked with boron, halogens and phosphorus and are prepared to develop a polyglycol system if necessary. Because of their position in halogens it would seem logical that they are attempting to use chlorine or bromine as a means to attain fire-retardancy.

3. Pittsburgh Plate Glass Co. reports that they will have a fire-retardant rigid polyether foam system on the market in about a month, for pouring in place and spraying. The system will be a two or three component type.

In addition, many of the recognized urethane system suppliers are adding built-in fire retardant formulations to their product line. These systems are generally of the semi-prepolymer type and sell for a certain premium as indicated above. These are based on the materials described in this article. End uses have been mostly in building and appliances (eg. refrigerators).

The question of toxicity when using halogens is being considered. Proponents of these systems maintain that gases are produced in non-fire-retardant foams anyhow, and that by the time any noxious gases may be evolved the damage to the building would be too great in any case. It is most important to keep the fire from starting.

In the case of phosphorus polyester systems, the problems of hydrolytic stability and dimensional stability has been raised. If these properties are poor, the significance is questioned in building applications.

Polyethers vs Polyesters

The situation in fire-retardant foams is a reflection of the situation in the industry at large. Although polyester foams are said to have superior properties, it is evident that the factor of economics will carry much weight as it has done in the case of flexible foams where polyethers account for about 85% of the total foam produced. Therefore the usage of fire-retardant foams should follow this trend especially where large low priced tonnages are required.

The cost of polyethers for foam is about $0.23-$0.29/pound, while polyesters are about $0.40-$0.45/pound with some being quoted higher. The finished foam cost however will depend on the type of formulation. A higher TDI to resin ratio will increase the foam cost.

Conclusions

Most interested companies are keeping active in research in the field but are waiting for the situation to break either way. Fire-retardancy may not always be necessary, viz. the masonry cavity wall, however the following reasons should increase the probability that they will be used.

1. They are available now and in general have acceptable properties.

2. Since they are available, it would seem logical to incorporate them into foams where there is a fire problem.

3. Fire-retardant foams could be more acceptable to building codes, underwriters and insurance companies.

4. Fire-retardancy as such, is a good selling point (as a bonus) to consumers especially where insulation and structural properties are available with the same foams. Also, self-extinguishing foams have obvious advantages for storage purposes.

5. The price differential between non-fire-retardant and fire-retardant foam should eventually be narrowed to the point where the premium for fire-retardancy will not be so great as to encourage use of non-fire-retardant material on an economic basis only, even when the need is not too obvious.

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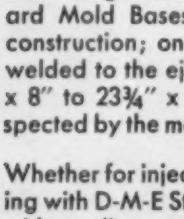

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Standard Tool Company

MOLDMAKING

Molds of the Future- A Forecast

Molds of the future will go into small, single purpose injection machines. Advantages are simple tool design, lower operating costs, and high production rates. This article describes four actual examples of how molders tried to use existing equipment, but because of operating difficulties, ultimately switched to single purpose equipment

One of the reasons tool costs skyrock out of proportion to overall costs of a particular job is that the molder, too often, projects the size of his mold for the wrong combination of machine size and part size. For instance, 48 cavity molds or 100 cavity molds might be built to run small parts in large equipment. The reverse in some instances is also true but of less consequence.

This is one of the cogent reasons why there are more and more captive molding plants and why there will be fewer custom molders. The captive molder has a product line which, in many instances, is uniform in size and homogeneous in shape. He can buy equipment for his own specialized purposes. Specialized or single purpose is the key word.

The Custom Molder Will Always be a Factor in Custom Molding, but . . .

- his numbers are dwindling
- only the most progressive and efficient companies will survive

Single-purpose equipment for high production items designed, developed and produced for the job at hand is the equipment of the future. Simplicity of tool design is possible because there are fewer cavities and, in some case, a single cavity. Such equipment also permits a forecast of lower maintenance, lower tool cost, and higher production rates.

Some Case Histories, examples of the results of a well thought out, engineering approach to molding a part follow:

Case History 1—A well-established custom molder with machines from 8 ounces to 100 ounces produced in this particular instance a small, linear polyethylene metal can spout, the plastic part having external thread which was mechanically stripped, molded the part using a 60-cavity mold in a 16-oz. press. The mold construction was 3-plate and required an operator to operate the machine and mold. Maximum production was 4200 pieces per hour due to the complexity of the mold—mainly due to the number of cavities. As little as 50% of the maximum production possible, at times was all that was obtained. This is an example of running a small part, large multiple cavity mold, in a large machine because it was available.

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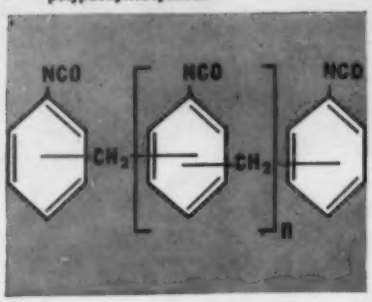

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Here was the solution—A 12-cavity mold, hot runner construction, operated in a 2-oz. high speed automatic machine, no operator in attendance, production rate 4800 pieces per hour, no scrap, with efficiency in excess of 95%.

Case History 2—A toy manufacturer, proprietary molder, designed and built molds for existing equipment, smallest machines being 4, 6 and 8 oz. presses of the latest design. Initially a 12-cavity mold was built containing 6 cavities of two different parts. Sales called for additional capacity, so a second mold of 16 cavities was built, 8 cavities of each two parts. To start out with a combination or mongrel mold, as it is called, requires the sorting of the parts. Results after a period of time: An unbalanced inventory, more pieces of one part than another due to molding problems plus cost of sorting. Sales again demanded additional output. A new approach was used whereby an 8-cavity mold of one part was built, and a 6-cavity mold of the second. Still there were problems and operations not satisfactory. Then, finally, molds were built for automatic operation in 2-oz. presses and the production equalled production from the two original molds with a savings of 50% in machine time, and a total savings of 25% in overall cost of the parts.

Case History 3—Along with the problem of building a mold for existing equipment, there is often another problem such as exists in the optical industry where, with the exception of some designs of sun glasses, there are a multiple of sizes of a product required to complete a line and the demand on these varying sizes is so unbalanced and so unpredictable that with large molds a serious, unbalanced inventory is commonplace.

To make a line of industrial goggles, for example, there are from 4 to 5 eye sizes and from 2 to 3 bridge sizes, with each eye size. Some sizes take only a few percent of the total output and one or two account for as much as 50 to 60% or more. Multiple cavity molds are often built with 8 cavities, sometimes 4 or 6, containing at least three different sizes of frames and sometimes in the case of the 8 cavities, as many as 4 or 5 sizes. The 8-cavity mold, a rather extreme example, was built because of the area required for the mold to fit into the 6 to 8 ounce press. The first week or two, all 8 cavities were run. The demand then indicated that all the production of one size was sufficient. This cavity was cut off.

The following week, production from one or two more cavities was stopped until eventually, only two or three cavities, making popular sizes, were running. Result? A 1½ or 2 ounce shot being molded in a large press at a high operating cost. If the cavities are not blocked off, one at a time as required, then inventory builds up which may never be translated into sales.

This company's solution was a 2-cavity mold, operated in a 2-oz. press, with extra cavities made interchangeable in the original mold. In addition to better control of production and inventory, there is an increased rate of production because of the fast-operating small machine and a savings in labor costs.

Again referring to goggles, the sun glass which does not have a variety of sizes, sometimes is produced in a combination mold where both frames and temples are molded at one time. A recent example was a 9-cavity combination mold containing 3 frames and 6 temples with tool cost approximately $12,000. A secondary operation was required for inserting for lenses calling for critical molding control of the material. In the secondary operation, rejects from various runs ran from 15% to as high as 35%. The solution was a 3-cavity combination mold containing one set of temples and one frame. Tool cost for this automatic mold was approximately 40% of the cost of the larger mold. The shorter cycle resulted in an overall savings of 15%. The reject rate due to the secondary operation was cut down to ½ of 1% and resulted in the profitable manufacture of a highly competitive item.

Case History 4—A linear polyethylene tube head was being produced by a manufacturer, using 12 cavities, a three—part mold, in 4, 6, and 8 ounce equipment, with a maximum production rate of 1600 to 1800 pieces per hour. The actual sprue and runner weighed in excess of the product molded in a given shot, but once molded was considered scrap, and, in this case, not recoverable. A hot runner mold was designed containing 8 cavities (and incidentally, at a considerable less tool cost than the 12-cavity mold). Production rate in an automatic 2-oz. press was about 2800 parts per hour, showing a substantial increase in production at lower tool cost and machine operating cost. But most important was that for every 50 pounds of material used, there was 50 pounds of product eliminating expensive material waste.

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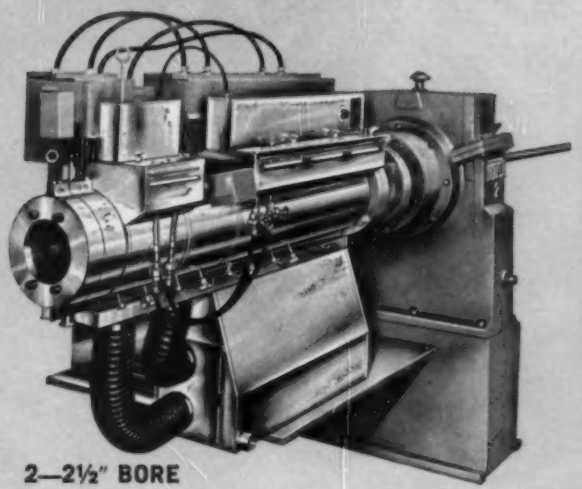

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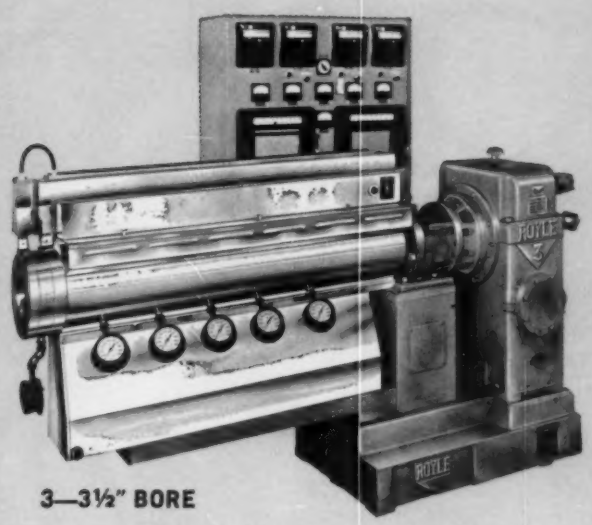

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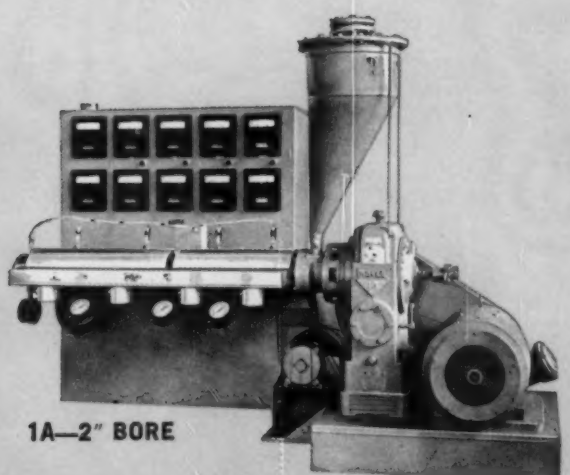

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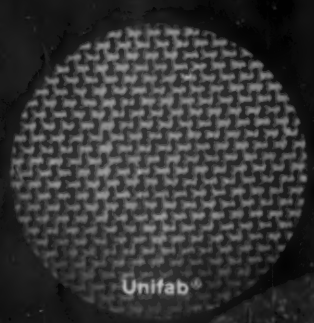

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REINFORCED PLASTICS

Service Life Estimates For FRP Structures

On Basis of Fatigue Tests

How long will a FRP boat last? This article describes dry land tests which may supply the answer for boats as well as other reinforced plastic structures

A need was recognized to devise means for estimating the minimum fatigue life to be expected of new FRP boats in service. The boats were tested in rough water to determine maximum cyclic deflections, and equipment was built and used to fatigue boat bottoms in the laboratory with a known multiple of cyclic service loads. A method (based on observation of FRP fatigue data) has been developed for interpreting boat fatigue-test results in terms of corresponding life in service. The results give order-of-magnitude life estimates. The test and analysis method may also be useful in other applications for FRP products.

Objectives and Test Procedure

Dry-land and laboratory fatigue tests were conducted on boat bottoms with a type of cyclic load similar to that of normal service but with increased amplitude.

The load system on a planing boat consists of propulsion thrust and frictional drag of air and water, horizontally, and the weights of engine, boat and passengers vertically, supported on a short wedge of water forced under the boat at high pressure. This vertical pressure is concentrated on a small part of the bottom surface and in rough water tends to pulsate between zero and some maximum value. The dynamic pressure supporting the boat during planing, acting over the planing area of the boat bottom, constitutes a pulsating force which deflects the bottom. This deflection was measured in top speed, rough-water tests on several boats, then converted in static load tests to an equivalent peak static service load. The laboratory fatigue tests were designed to apply a known multiple of the pulsating service load to the area of peak planing pressure on the bottoms of the inverted boats. The boats were supported at transom and forward seat locations. The laboratory fatigue setup and machine are shown in *Figure 1*. Principal elements of the fatigue machine are a hydraulic pump, 4-way valve with reverse controlled by peak cylinder pressure, and 4 hydraulic cylinders with swivelling rubber-faced pads for force application.

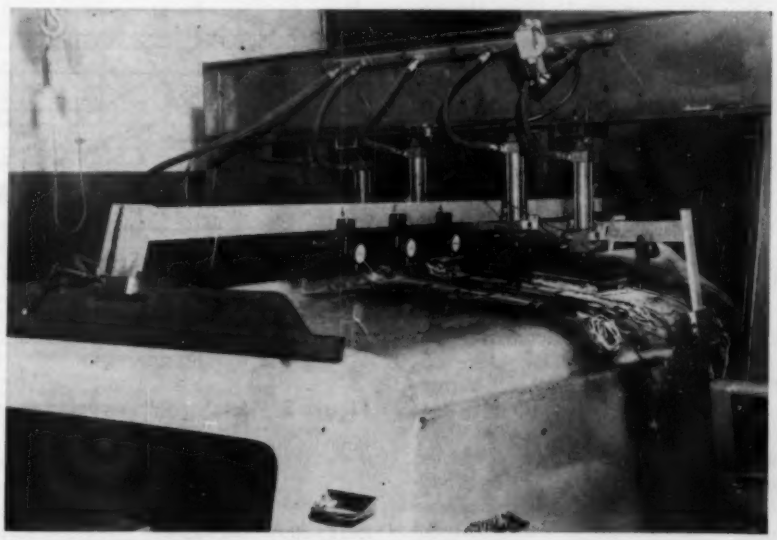

Figure 1. Inverted boat hull in fatigue tester

Table 1. Failure Strain vs Cycles for Various FRP Laminates and Test Conditions

Cycles N	Laminate Material and Condition of Fatigue Test: 181 Cloth—Polyester Ref. (1) Wet Cyclic Strain Reversed E = 2.89 x 10⁶ p.s.i.		181 Cloth—Polyester Ref. (1) Dry (50% R.H.) Cyclic Strain Reversed E = 3.23 x 10⁶ p.s.i.		Dry (50% R.H.) Cyclic Strain 0 to Max. Tens. E = 3.23 x 10⁶ p.s.i.		Mat-Polyester Ref. (1) Dry Cyclic Strain Reversed E = 1.1 x 10⁶ p.s.i.		181 Cloth—Epoxy Ref. (1) Wet Cyclic Strain Reversed E = 2.94 x 10⁶ p.s.i.		181 Cloth—Epoxy Ref. (1) Dry Cyclic Strain Reversed E = 3.04 x 10⁶ p.s.i.	
	$\epsilon_{max.}$, $\mu''/_{''}$	Δ	$\epsilon_{max.}$, $\mu''/_{''}$	Δ	$\epsilon_{max.}$, $\mu''/_{''}$	Δ	$\epsilon_{max.}$, $\mu''/_{''}$	Δ	$\epsilon_{max.}$, $\mu''/_{''}$	Δ	$\epsilon_{max.}$, $\mu''/_{''}$	Δ
10^3	6900	—	10,000	—	10,000	—	8650	—	9800	—	9750	—
10^4	5500	80	6500	65	8100	81	6100	70.7	7950	81.2	8600	88.5
10^5	4500	81.7	4810	74	6200	76.5	5100	83.7	7320	92.5	7450	87
10^6	3850	85.5	3850	80	4620	74.8	4200	82.5	6800	93	6380	85.5
10^7	3250	84.2	3220	83.5	3730	81	3200	76.1	5700	84	5300	83.5
Avg. Δ		82.8		75.6		78.3		78.2		87.8		86

Δ = Percent of Previous Failure Strain, @ N/10 cycles.
ϵ = Peak Strain, Microinches per inch.

Reference: (1) "Fatigue Properties of Fibrous Glass-Reinforced Plastics Laminates Subjected to Various Conditions." K. H. Boller, Modern Plastics, June 1957; Tables II, IV, and VI.

To provide quick results, the cyclic load was set 3 times as high as the equivalent peak service load. Strains and deflections were measured at various points on the boat periodically throughout the tests, and load cycling was continued until definite fatigue cracks showed in the boat hulls. It was then necessary to answer the question, "How many cycles would this boat have lasted under the service load?"

The analysis method used assumes the boat itself to be merely a large specimen holder for the small, high-strain FRP areas which will fail. On this basis, fatigue failure would always occur at these weak points, if at all, and with a strain vs. life relationship specified by fatigue data for the FRP material involved.

It is not necessary to know the actual strain at the point where the structure will fail. It is sufficient to know the *ratio* of test and service strains and the number of cycles at which the structure fails under test. Then, knowing the strain vs. cycles characteristic of the particular material in the structure, one can predict what the service life in cycles will be.

Fatigue Curve Analysis

Table 1 lists peak strains at failure vs. cycles to failure as calculated from data by Boller (1). They were obtained by direct loading, i.e. alternating tension and compression stresses superposed on a mean tensile stress which for most tests was 0. Listed strain values were obtained by dividing the reference authors' tabulated stresses at failure by the material modulus of elasticity.

The materials considered are epoxy and polyester laminating resins, with 181 glass cloth and, for the latter resin, chopped glass mat. Some comparison can be made of wet and dry environments. Only room-temperature ambients were considered.

Strain instead of stress has been treated because, at any given number of cycles, the disparity of values within a variety of laminates is quite small. Similarly, for static loading, although the *stress* at which different laminates with a given reinforcement fail varies widely, the strain at failure usually lies in the range of 2.1% to 2.6%—the limiting strain of the glass fibers—regardless of the *form* of reinforcement.

Figure 2 shows a plot of strain, ϵ, vs. number of cycles, N, from *Table 1* for polyester-glass laminates. Data sets include as variables humidity (50% and 100%), labeled "dry" and "wet"; strain cycle (alternating compression and tension, and 0 to max tension); and reinforcement (181 cloth and mat). Curves of the form $\epsilon = \frac{A}{N^k}$,

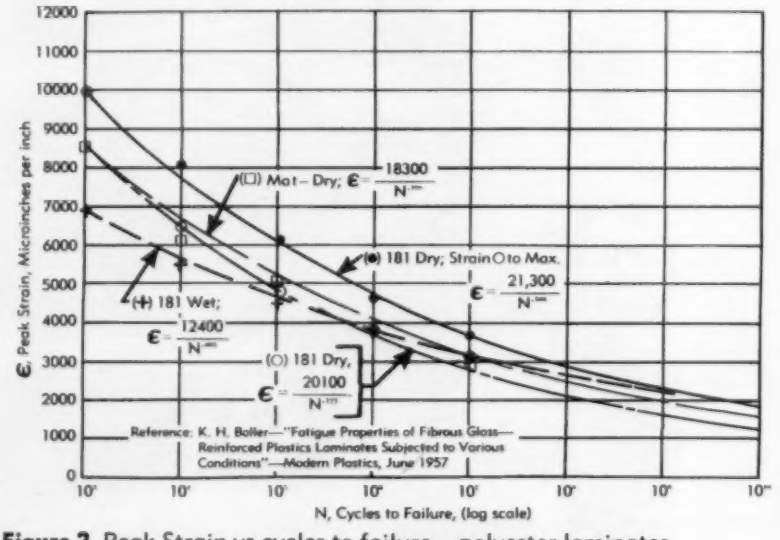

Figure 2. Peak Strain vs cycles to failure—polyester laminates

Rational curves of form, $\epsilon = \frac{A}{N^k}$ with

Data Points from Table I Plotted in.

ϵ = Peak Strain, $\mu''/_{''}$
A = Curve Constant, μ''—cycles/"
N = No. of cycles to failure
k = Degradation exponent
Cyclic strain = $\pm \epsilon$ except as noted.

applicable to fatigue data of many other materials, have been drawn through these plotted data points.

Figure 3 shows similar data plots and curves for 181 cloth-epoxy resin laminates, in 50% and 100% relative humidity environments. Data for *Figure 3* were extracted from *Table 1* and from a report by Stevens and Boller (2).

The exponential curves $\epsilon = \frac{A}{N^k}$ drawn through FRP fatigue test data points were drawn by inspection as straight lines on log-log paper. They are presented in *Figures 2 and 3* on semi-log paper for ease in visual discrimination between the various curves.

The fit of these arbitrary exponential curves to the test data cited is, in general, quite good. It leads to the tentative conclusion that the failure characteristic of the FRP laminates considered is one of constant degradation rate of peak strain at failure with increasing cyclic life.

Projecting these observations to the problem at hand, estimating service life of a structure which has failed at some number of cycles N_t in an accelerated laboratory test, we would deal with a ratio R between peak strain in the structure under the test condition and peak cyclic strain at the same point in the structure under a service load condition. For the material or the structure,

$$\epsilon_t = \frac{A_t}{N_t^{k_t}} \text{ and } \epsilon_s = \frac{A_s}{N_s^{k_s}} \quad \ldots\ (1)$$

Where: ϵ_t and ϵ_s are peak strains in test and service, respectively;
A_t and A_s are intercepts at $N = 1$ on log-log curves for test and service materials, respectively;
N_t and N_s are life in cycles under test and service conditions; and
k_t and k_s are absolute values of slope of test and service material log ϵ vs. log N curves, respectively.

$$R = \frac{\epsilon_t}{\epsilon_s} = \frac{A_t N_s^{k_s}}{A_s N_t^{k_t}} \quad \ldots\ (2)$$

$$\frac{N_s^{k_s}}{N_t^{k_t}} = R\frac{A_s}{A_t} \quad \ldots\ (3)$$

$$N_s = N_t^{\frac{k_t}{k_s}}\left(R\frac{A_s}{A_t}\right)^{\frac{1}{k_s}} \quad \ldots\ (4)$$

(4) would provide for estimation of N_s when the materials for the laboratory structure and the service structure were different, and would require knowledge of constants A and k for both materials. If the laboratory and service structures are of the same material,

$A_s/A_t = 1$ and $k_t/k_s = 1$. For this case, (4) reduces to:

$$N_s = R^{\frac{1}{k}}N_t \quad \ldots\ (5)$$

In the case where laboratory and service structures are of the same material, one can obtain an estimate of N_s, the number of cycles of service life, from a knowledge of N_t, the cycles to failure on test; R, the ratio of peak test and service strains; and k, the absolute value of the slope of the log ϵ vs. log N curve.

The predicted value of N_s will be in error from the true value as a consequence of errors in estimating *k* and *R*. This situation has been analyzed and will be discussed later.

Determination of R—Equations (4) and (5) do not specify the nature of the structure tested, only that R, a ratio of peak test and service strains be determined. If the structure is linear, i.e., has a linear load-deflection or load-strain relationship thruout, strains at all points will be in proportion and hence R can be the ratio of test and service loads, deflections, or strains at any one point on the structure. Non-linear structures, on the other hand, require that the test-service strain ratio be determined at the point of failure, and in this case it is desirable to seek the area of peak strain on the structure, and locate strain measuring devices in this area under both test and service conditions before the laboratory fatigue test is started. In the case of the boat test discussed before, an effort was made to locate the peak strain area by use of brittle lacquer coatings and an initial deflection duplicating that measured in the service, rough water operation.

Determination of k—The values of k assigned to various curves in Figures (2) and (3) are in each case the best estimate which could be made for the available fatigue data. *k* is observed to be somewhat variable between the two resins selected and various test conditions, but can be selected for those applicable to the structure tested. For the data considered, k has an average value of 0.105 for polyester laminates and .0714 for the epoxy laminates—a measure, incidentally, of the superior fatigue durability of epoxy laminates.

Error Analysis—The reliability of N_s as predicted from N_t depends on the precision with which R and k have been estimated. We are especially concerned with avoiding errors which will make the actual value of N_s lower than that predicted. The accompanying *Table 2* shows the ratio $\frac{N_s}{N_t} = R^{\frac{1}{k}}$ with ± 5% variations and ± 10% variations in R and k simultaneously, from nominal values of R = 3.0, and k = .105.

All error combinations below the light line of *Table 2* give $\frac{N_s}{N_t}$ values

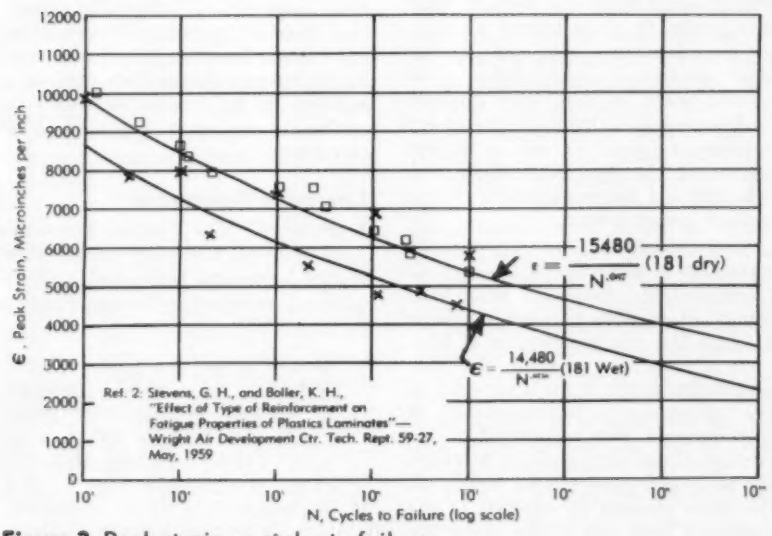

Figure 3. Peak strain vs cycles to failure

181 cloth-epoxy laminates (room temperature). Data points from Table I and from Ref. 2.

x = 181 cloth—epoxy (wet)

□ = 181 cloth—epoxy (dry)

ϵ = Peak strain, microinches per inch.

N = Cycles to failure.

Mean stress = 0.

$\epsilon = \frac{15480}{N^{.097}}$ (181 dry)

Table 2. $\frac{N_s}{N_t}$ and Percentage Error $\Delta\left(\frac{N_s}{N_t}\right)$ as a Function of Estimation Errors in R and k*

k (Actual) \ R (Actual)	2.70 (−10%)	2.85 (−5%)	3.00 (Nominal)	3.15 (+5%)	3.30 (+10%)
.1155 (+10%)	$N_s/N_t = 5260$ $\Delta(N_s/N_t) = -86\%$	8420 (−75%)	13,100 (−61%)	19,500 (−42%)	30,300 (−10%)
.112 (+5%)	7170 (−79%)	11,400 (−66%)	18,300 (−46%)	27,700 (−18%)	42,200 (+24%)
.105 Nominal	11,600 (−66%)	21,200 (−38%)	33,900 (Ref.)	54,300 (+60%)	86,700 (+156%)
.100 (−5%)	20,500 (−41%)	35,300 (+4%)	59,300 (+75%)	95,900 (+183%)	154,000 (+355%)
.0945 (−10%)	36,700 (+6%)	64,900 (+91%)	113,000 (+234%)	184,000 (+443%)	313,000 (+924%)

Note $\frac{N_s}{N_t} = \frac{\text{Service Life, Cycles}}{\text{Test Life, Cycles}}$; $\Delta\left(\frac{N_s}{N_t}\right)$ = % Error in Predicted $\left(\frac{\text{Service Life}}{\text{Test Life}}\right)$ Ratio.

less than −50% in error. All error combinations below the heavy line give $\frac{N_s}{N_t}$ values which err on the + side, and are, therefore, conservative.

R values in excess of 3 would seldom be employed. In fact, a similar error table for R = 2 or R = 1.5 would show much lower percentage errors in N_s/N_t for the same percentage estimation errors in R and k. It is desirable to select R within a range of 1.5 to 2.5. Further, it should be possible to fix R within 5% of its true value, and if the estimate of k is high relative to its true value, the estimated N_s will generally be conservative.

Example—Suppose there is under test a boat such as that shown in *Figure 1* Suppose also there has been selected a test loading which produces a peak strain in a region of high strain 3 times as high as that measured when the service deflection was duplicated.

Assume also:

(a) N_t = 2000 (actual values are generally much higher)

(b) Laminate is 181 cloth and polyester, loaded 0 to maximum in bending.

k assumed to be 0.108; $\frac{1}{k} = 9.26$

Then: $N_s = N_t R^{\frac{1}{k}} = 2000 \times 3^{9.26}$

$3^{9.26} = 2.58 \times 10^4$

and $N_s = 2 \times 10^3 \times 2.58 \times 10^4 = 5.16 \times 10^7$ cycles.

Discussion

Examination of fatigue data for several common FRP laminates and test conditions has shown reasonably good correlation with an assumed exponential characteristic of strain degradation with number of cycles of strain. This characteristic has then been used as a basis for estimating service life—in cycles—of structures made with these laminates when certain life and strain ratio data were available from an accelerated laboratory fatigue test on the structure.

No account has been taken of other environments, such as various hydrocarbons or chemicals, which might affect the value of k. Further, the analysis method has been based on strain degradation—life tests in uniaxial strain. It is not known whether the same k values would apply for biaxial or triaxial strain fields. The method could be used with greatest confidence where dominant strains *are* uniaxial or nearly so, and with less confidence in hydrostatically-loaded cylinders and spheres where a biaxial strain is known to exist.

Most structures are exposed in service to a spectrum of loads, with corresponding variable strain-time history. Test data are not available to show the relative damage of mixtures of such strains on the FRP materials considered, but it is known that the high strains are most damaging. If it is assumed that a reasonable percentage of the service strains less than the measured peak service strains do the same amount of damage as the measured peak strains, the cyclic life estimated will be conservative.

It would be desirable to compare service life predictions by the method presented with actual experience. Boats of the type tested have been in service for approximately 5 years at most. The lives predicted by our tests and fatigue analysis exceed any reasonable number of cycles which might have been accumulated in this time, hence an evaluation of the method on this basis is not possible at present.

Conclusion

A procedure has been discussed whereby a dry-land fatigue test was made on FRP boats. Means were discussed for projecting the life on test to an equivalent fatigue life order of magnitude in service, based on an observed fatigue life degradation-strain-characteristic for the type of FRP material used. Although time and experience have not permitted a correlation to be made between theory and service experience, the analysis method is believed to be rational and may be applicable to other types of FRP structure.

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—— ■ ——

Edited by
George Lubin
Grumman Aircraft Engineering Corp.

For Printed Circuit and Terminal Board—

Epoxy-Mica Paper Laminate Reinforcement

E. G. Dingman

The Macallen Co., Inc.

Mica paper can be used to make laminates having electrical and physical properties equal to those of epoxy-glass laminates. Also of interest: Potential cost of mica reinforcement, is about one-third that of fiber-glass

Mica has a long history as an insulating material in the electrical and electronic industries. Its stability in severe environments is well known. Its dissipation factor ranks it at the top of the list among low-loss materials. But, mica is a natural material and is not available in large pieces and this, of course, limits its usefulness. A form of laminated mica, "built up mica", or "segment plate" has been used as insulation in commutators of electric motors for many years. Segment plate is often rough surfaced and brittle. The traditional binder for segment plate is shellac. Segment plate made with shellac has little resistance to water and when wet delaminates to form a soft, spongy mass. This type of material, although satisfactory in rotating equipment, is of limited usefulness elsewhere.

Mica Papers

Within the last five to ten years a new form of mica has become available, the mica papers, which in combination with synthetic resins form a material very different from segment plate. These papers are of two principal types, reconstituted mica and integrated mica. Reconstituted mica receives a thermal treatment during processing which results in some alteration whereas integrated mica is composed of tiny particles of basically unaltered natural mica. These papers when laminated using synthetic resins produce laminates of outstanding electrical properties, as might be expected. The physical properties are also excellent. Properties are comparable in most respects with those of epoxy—glass laminates and are superior to them in several important aspects.

Preparation of laminates in this work was done with epoxy resins.* Epoxies were found to be superior to polyesters in moisture resistance and in ease of fabrication and therefore were used. Recent work indicates that several other resins may be of value. Impregnating and laminating techniques were conventional. Two types of mica papers were used in this investigation; a four thousandths thick integrated mica paper based on phlogopite and a four thousandths thick reconstituted mica based on muscovite. These papers gave somewhat similar laminates with reconstituted muscovite having superior properties in general. The integrated phlogopite materials cannot be ignored, however, since they possess a few properties peculiar to them which may make them useful in a particular application, such as softness and a lower dielectric constant.

An insight into the physical and electrical properties of mica may be had from an examination of its structure. The micas are members of a complex series of sheetlike materials known as phyllosilicates. The series includes kaolinite, or china clay; serpentine and its commercially valuable variety chrysotile or asbestos; talc, and the mica group as well as several other minerals. The whole series shows a tendency to cleave into plates or fibers. Asbestos has been used in laminates for a long time; kaolinite and talc have been used extensively as fillers in plastic compositions and the micas might, by inference, be expected to be useful in similar applications. Mica is tough, elastic, strong and has the ability to cleave easily into extremely thin sheets with a large ratio of width to thickness. When handled properly the mica sheets will pack into a sheet with little free space between the particles. It is this property which makes possible the manufacture of laminates with high mineral content —above 80% by weight and as high as 95%. These laminates are essentially void free in spite of their low resin content. With such high mineral content an approach to the properties of mica itself can be expected and actually in some areas properties are somewhat better, particularly those properties which are involved with surfaces or notch sensitivity. In these cases, the resin distributes the applied forces over an area rather than at

Editor's Note: One referee of this manuscript suspected that the mica paper would be extremely weak during coating. However, according to the author, the paper is weak while wet, but recovers when dry, and needs to be supported on wire mesh screen during impregnation.

a point and results in improved properties by reducing stress concentration.

If ductile material (e.g. copper foil) is laminated to a mica laminate, peel strength is poor because of the tendency of the mica flakes to split along their plane of cleavage. Cleavage occurs mostly in the mica and the surface obtained is a shiny one composed almost completely of mica. If a thin layer of another material such as fiber glass is laminated in between the copper foil and the mica board, peel strength is increased to satisfactory levels. The fiber glass or other material needs to be only two to three thousandths of an inch to accomplish a very large improvement in peel, amounting to an increase of ten to one hundred fold. In practice 116 Volan A fiber glass (saturated with resin) was used. The very edge of the laminate is, of course, still subject to peel but if the edges are chamfered slightly, little or no difficulty is encountered.

Comparison with Other Materials

Laminated mica is a material offering a combination of properties not obtainable in other materials, most of them of considerable value in printed circuits and in terminal board. The physical properties are in general comparable to those of aluminum, including modulus of elasticity. The high modulus allows the use of a much thinner laminate than the usual one, which compensates largely for a somewhat higher cost and density. The coefficient of expansion is low for a laminate and can be matched to that of copper by control of resin content. With such a close match there is little or no warping during thermal cycling and there is little or no shear force developed at the copper—laminate interface. A reduction in delaminating and peeling of etched circuits is therefore to be expected.

Low resin content is an easily achieved characteristic in mica laminates. The low resin content results in fire retardency and low moisture absorption. The mechanical properties of mica paper laminates are in general better than those reported for mica alone. Mica, like fiber glass, is a somewhat brittle material and is notch sensitive. It does not stretch if its elastic limit is exceeded. Improvement is probably because the forces are better distributed in a resin mica laminate and stress concentrations are minimized.

Physical properties are listed in *Table 1*. Properties are above those required for a NEMA G-11 laminate in every respect and in several areas are much better. High temperature data are given for information purposes although these data are probably more a function of the particular resin used than that of the mica reinforcement.

Only limited work has been done on mica laminates in regard to their fatigue resistance in vibration. A sample was vibrated at 100 cps, its resonant frequency and at an amplitude just below its elastic limit for nine hours. At the end of the period there was no evidence of damage. This is in agreement with other and more detailed studies of similar materials.

Electrical properties are excellent, as expected. There was some difficulty experienced with integrated mica specimens which were placed in high humidity. The inconsistencies may have been due to the presence of small voids or other imperfections, but time did not allow a further check on these properties. Electrical properties are listed in *Table 2*. Dielectric constant and dissipation factor at radar frequencies have not been run. It would be expected that they would be only fair to poor since epoxies are usually only fairly good at high frequencies. If lower loss resins were used, a high frequency material might be obtained.

Mica is an abundant natural material; not just readily available, but abundant. It is one of the principal rock forming materials in the earth's crust. It follows that it should be available, as fine flakes at least, in large quantity at low cost. This is indeed the case and dry ground mica may be had at as little as five cents per pound, in virtually unlimited quantities. Therefore no shortage of reinforcing material is to be anticipated. The price of mica laminates should, eventually reach a figure appreciably lower than that of glass laminates and perhaps even lower than that of paper laminates. No shortage of this kind of mica would be anticipated during a national emergency since most ground mica, amounting to many thousands of tons per year is of domestic origin.

In summary, mica paper may be used as a reinforcing material to make electrical laminates which have electrical and physical properties equal to an epoxy—glass laminate and in addition offering stiffness, fire retardency, retention of properties, a

Table 1. Typical Physical Properties of Mica Paper—Epoxy Laminates[1]

Resin: Novolac Epoxy, Amine Cured Approx. 20% by wt.

Mica Paper Type:		Integrated (Phlogopite)	Reconstituted (Muscovite)
Flexural Strength	Room temp	58,000	60,000
	500°F	11,500	17,000
Tensile Strength	Room temp	37,000	38,000
	500°F	10,000	11,000
Compressive, flatwise	Room temp	20,000	not run
Compressive, edgewise	Room temp	8,000	17,000
	500°F	3,600	5,300
Shear Strength	Room Temp[4]	19,000	19,000
Flexural Modulus	Room temp	12.4×10^6	10.5×10^6
	500°F	3.0×10^6	5.7×10^6
Tensile Modulus	Room temp	15×10^6	12×10^6
Specific Gravity		2.4-2.6	2.4-2.6
Flammability, ASTM D568-56T		Self Ext.	Self Ext.
Coefficient of expansion (°C)		$9\text{-}14 \times 10^{-6}$	$9\text{-}14 \times 10^{-6}$
Machinability[2]		Fair-good	Fair-good
Heat Resistance[3]		350-500°F	350-500°F
Peel Strength, clad laminates 1 oz, PIW		9-12	9-12
Moisture absorption, 28 days immersion		.04%	.03%

[1] Flexural, tensile and compressive properties obtained as outlined in Federal Specification LP 406 B.
[2] Ordinary steel tools satisfactory but require frequent sharpening. Material is softer than fiber glass but harder than paper.
[3] Depending on operating conditions and requirements.
[4] Johnson Punch (Test Method 1041) using a cylindrical specimen.

Table 2. Electrical Properties of Mica Paper—Epoxy Laminates[1]

Resin: Novolac Epoxy, Amine Cured Approx. 20% by wt.

Mica Paper Type:		Integrated (Phlogopite)	Reconstituted (Muscovite)
Dielectric Constant			
as recd., plain board	60 cycles	2.82	3.08
	10^3	2.76	3.06
	10^6	2.60	2.94
after 24 hr in H_2O, RT	60 cycles	—[2]	4.25
	10^3	5.98	3.27
	10^6	3.04	3.01
Dissipation Factor			
as recd., plain board	60 cycles	.020	.0039
	10^3	.010	.0042
	10^6	.006	.0056
after 24 hr in H_2O, RT	60 cycles	—[2]	.15
	10^3	.93	.052
	10^6	.034	.0097
Dielectric Strength, VPM S/T, as recd.	1/32, in. thick	1000	1200
	.003, in. thick	1300	1600
Arc Resistance, Sec. 96 hr 96% RH, 23°C	Plain	35	179
	Clad, Copper removed[3]	177	159
Volume Resistivity, ohm/cm			
as received	Plain	1.32×10^{15}	3.71×10^{15}
	Clad	1.68×10^{15}	3.40×10^{15}
after 96 hr at 96% RH, 23°C	Plain	9.12×10^{14}	9.28×10^{14}
	Clad	1.1×10^{12}	5.23×10^{14}
Surface Resistivity, ohms/cm			
as received	Plain	1.32×10^{15}	3.7×10^{15}
	Clad	9.12×10^{14}	9.28×10^{14}
after 96 hr at 96% RH, 23°C	Plain	2.37×10^{14}	9.05×10^{14}
	Clad	6.5×10^{7}	6.77×10^{15}

[1] ASTM test methods used throughout.
[2] Off scale of test instrument.
[3] Surface is adhesive supported by .003 epoxy glass to aid in adhesion.

coefficient of expansion close to copper and several other properties unique to mica laminates.

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Acknowledgment

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Edited by
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1961 REGIONAL TECHNICAL CONFERENCES (RETEC)

October 5—Plastics Foams sponsored by Buffalo Section. Section President: William Dunmyer, c/o The Carborundum Co., Building 71-1, Buffalo Ave., Niagara Falls, N. Y.

October 25—Plastics in Major Household Appliances sponsored by Kentuckiana Section, Monogram Hall, Appliance Park, Louisville, Ky, Chairman: Ray E. Eshenaur, c/o General Electric Company, AP-5-249, Appliance Park, Louisville, Ky.

November 2-3—Plastics in Packaging and SPE Southwestern Packaging Exhibition on November 1, 2, 3. RETEC sponsored by North Texas Section and Exhibition by Section with cooperation of Southwestern Division Chapter, Society of Packaging and Handling Engineers, Sheraton-Dallas Hotel, Dallas, Tex. Chairman: Peter W. Kent, 3637 Mid Pines Drive, Dallas 29, Texas.

November 15—Vinyl Plastics in the Household sponsored by New York Section with cooperation of Vinyl Plastics PAG, Statler Hilton Hotel, New York, N.Y. Chairman: Saul Gobstein, c/o Ferro Chemical Co., Box 607, Emerson, N. J.

December 1—Plastics Screw Injection Molding sponsored by Cleveland Section, Cleveland Engineering Society Building, Cleveland, Ohio. Chairman: Edward J. Haskins, c/o Injection Molders Supply Co., 17601 South Miles Road, Cleveland 28, Ohio.

Offers of papers for presentation at these Regional Technical Conferences are invited. Please address offers to RETEC Chairman or Section President.

ANNUAL TECHNICAL CONFERENCES (ANTEC)

January 30-February 2, 1962—18th ANTEC, Penn-Sheraton Hotel, Pittsburgh, Pa. Sponsored by Pittsburgh Section. General Chairman: John E. Parks, H.P.M. Division, Koehring Co., 512 Empire Building, Pittsburgh 22, Pa.

January 22-25, 1963—19th ANTEC, Ambassador Hotel, Los Angeles, California. Sponsored by Southern California Section. General Chairman: A. R. Tucker, Jr., c/o Dow Chemical Co., 900 Wilshire Blvd., Los Angeles 17, Calif.

January 28-31, 1964—20th ANTEC, Chalfonte-Haddon Hall, Atlantic City, N. J. Sponsored by Philadelphia Section. For information write Executive Secretary Thomas A. Bissell, Society of Plastics Engineers, Inc.

January 18-22, 1965—21st ANTEC, Boston, Mass. Sponsored by Eastern New England Section. For information write Executive Secretary Thomas A. Bissell, Society of Plastics Engineers, Inc.

TECHNICAL MEETINGS CALENDAR

HIGH SPEED TESTING

October 26-27—Third Annual Symposium on High Speed Testing, sponsored by Plas-Tech Equipment Corp., Hotel Somerset, Boston. Chairmen: Alfred G. H. Dietz, Massachusetts Institute of Technology, and Frederich R. Eirich, Polytechnic Institute of Brooklyn.

CORROSION CONFERENCE

October 9-11—St. Louis; October 30-November 2—Houston; November 27-December 1—Miami; Plastics to Combat Corrosion will be covered at the four regional conferences of the National Association of Corrosion Engineers.

A.I.Ch.E. MEETING

September 24 — Forty-Sixth Annual Meeting of the American Institute of Chemical Engineers on management theme. Lake Placid Club, Lake Placid, N. Y. Chairman: J. J. Healy, Monsanto Chemical Co.

BUILDING MATERIAL TRADE SHOW

October 7-10—First Annual Western Building Industries Exposition, Great Western Exhibit Center, Los Angeles.

STANDARDS

October 10-12, Twelfth National Conference on Standards, Rice Hotel, Houston, Texas. Sponsored by the American Standards Association Inc., National Program Chairman: H. C. Ball, Humble Oil and Refining Co.

CANADIAN PLASTICS SHOW

October 17-19—Plastics Show of Canada, Automotive Building, Exhibition Park, Toronto, Ont.

PACKAGING FORUM

October 18-20—Twenty-Third Annual National Packaging Forum, sponsored by the Packaging Institute, Biltmore Hotel, New York.

RHEOLOGY MEETING

October 30-November 1—Thirty-Second Annual Meeting of the Society of Rheology, University of Wisconsin, Madison, Wis.

THE PLASTICS INSTITUTE

October 31-November 1—Engineering with Plastics, sponsored by the Institution of Electrical Engineers. London, England.

U.S.I. POLYETHYLENE NEWS
A series of advertisements for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

Packaging Notes

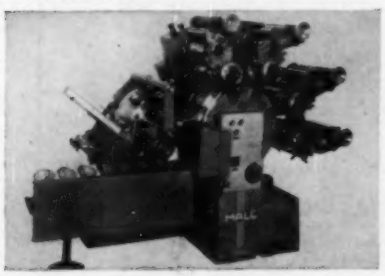
Reusable closure for polyethylene bags is airtight — protects against humidity, leakage, odors, mildew, hardening, de-

composition. Easily attached, it comes in three sizes and a range of colors; is especially suitable for rack display and tie-in merchandising. This clip, originated in France, has been widely used in Europe for packaging foods, chemicals, drugs, precision instruments, notions, sweaters. A Yonkers, N. Y., company is the American manufacturer and distributor.

Adjustable-flow bottle for hydrofluoric acid is molded entirely of polyethylene. Unique closure (design patented) permits user to actually "dial" the rate of flow—from a single drop to a steady stream. There's no diaphragm to puncture: the one-pound container has a slip-on dust cover which protects against contamination and leakage.

New primer, said to be an excellent adhesion promoter, does away with the need to age film surfaces prior to extrusion coating with polyethylene. Can be used on cellophane, polyester, aluminum, many other films and foils. Application is by wash coat. Coverage: 10 lbs. per 3,000 sq. ft. wet.

Offset printing machine decorates round and tapered polyethylene containers and bottles in four colors at a production speed of 80 pieces per minute, maximum. It handles bottles up to 13 inches high, four-inch diameter full circumference and six-inch diameter ⅔ of circumference.



First Commercial Products Of U. S. I.'s Powdered Polyethylene Introduced

Outsize Items Molded from MICROTHENE® by New Technology

One ton-capacity meat tanks, nine-foot long boats and 13-gallon containers are among the first products made of powdered polyethylene to be marketed in the U.S. All three are being produced by powder molding. This is a new polyethylene technology used in Europe, but relatively unknown in America until U.S.I.'s MICROTHENE became available nearly two years ago.

Tough, lightweight boat hull is made from U.S.I.'s MICROTHENE finely-divided polyethylene. It will retail at a price lower than comparable boats of reinforced plastics.

Process is fast, easy, economical

Larger than ordinary moldings can be made from powdered polyethylene. The process is fast and requires simple, relatively inexpensive molds. Ease and economy of production give many items made by this method a price advantage over those molded by conventional procedures.

The new boat, molded from black MICROTHENE by an Indiana company, is typical. It has the first full-sized hull made of conventional polyethylene, without the use of wood or metal inserts for stiffening. It will retail at a price lower than comparable boats. It won't rust or dent. Can be used with outboard motors up to 5 hp.

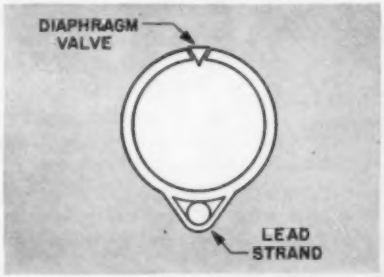
The same company utilizes MICROTHENE to produce a meat tank for use in packing and processing plants. It is thick-walled, easily cleaned and resistant to juices and chemicals; holds one ton of liquid or bulk product.

The 13-gallon MICROTHENE "bottle", produced in Brooklyn, N. Y., is lighter and takes less storage space than the glass carboys it's designed to replace. It is also unbreakable and corrosion resistant — characteristics which virtually assure its success in the chemical industry. The manufacturer has received ICC certification for the 13-gallon container. The company can reportedly produce up to 800 of the units in a normal 40-hour production week.

Extra-large meat tank made of MICROTHENE—designed for transporting, storing or process-handling meats—is one of the first results of the new polyethylene technology called powder molding.

Ice Melting System Uses Polyethylene Tubing

Weighted polyethylene tubing is an integral part of an automatic aerating and ice melting system currently being marketed. The equipment, inexpensive to install and operate, is designed to provide year-round open water for wildlife sanctuaries . . . prevent winter fish-kill . . . and eliminate ice damage to docks, piers, boats, locks, dams, etc.



As shown in the schematic drawing, the tubing has a built-in strand of lead along the bottom and diaphragm valves at given intervals along the top.

During service, needle-point amounts of oil-free air are forced into the water through the valves in the submerged hose. The air gently circulates the earth-warmed bottom water — which aids in ice melting. The air also furnishes oxygen for the fish, and for burning up organic debris.

U.S.I.

Series VI, No. 5

POLYETHYLENE PROCESSING TIPS

HONING AND REPLATING EXTRUDER DIE LANDS

Cleaning and polishing the die lands of polyethylene film extruders and extrusion coaters on a regular basis will minimize the amount of poor quality production resulting from contaminated die lands. Procedures for such maintenance were outlined in a previous *U.S.I. Polyethylene Processing Tips*—Series VI, No. 4.

Even with the best care, however, it still is necessary to refinish the die lands periodically either by honing or, if they are chrome plated, by replating. Lands need refinishing if they have rough spots (as shown by lines in the polyethylene film or coating) that cannot be eliminated by cleaning and polishing.

Honing Flat Film Die Lands

The procedure for honing flat film and extrusion coater die lands is as follows:

1. Fabricate a holder of soft material that will not mark the lands for the honing stone, similar to the one shown in Figure 1. Wood or Micarta plastic are two suitable materials for the holder.

2. Be sure the lands are cool before honing. Hot lands are easily marked.

3. Place the lands, or jaws if they are in one piece, in a table vise so that the lands are upright. See Figure 2.

4. Hone the lands, keeping the stones wet with kerosene during the entire honing operation.

- Start with a 400 grit stone in the holder. Hone the lands until all visible imperfections are removed.
- Follow with a 600 grit stone. Continue honing until a very smooth surface is obtained.
- If desirable, hone briefly with an 800 grit stone for a mirror finish.

Precautions During Honing

While the die lands are being honed, it is extremely important to hold them in an upright position in a rigid mounting block or vise, as shown. The stone must be positioned firmly in the holder so that the stone will be flat against the lands' surface at all times. Never try to hone only a small area of the lands—hone across their entire length with smooth, even strokes. As you hone, be sure to keep the stone free from small bits of metal. These will undo your work by scratching the die lands.

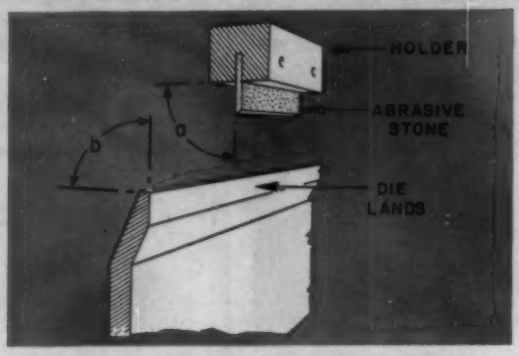


Figure 1—Honing stone and holder for honing flat film or extrusion coater die lands. Notice that angle between holder and stone (a) corresponds to angle between die land and face of die lip (b), 90° in this case.

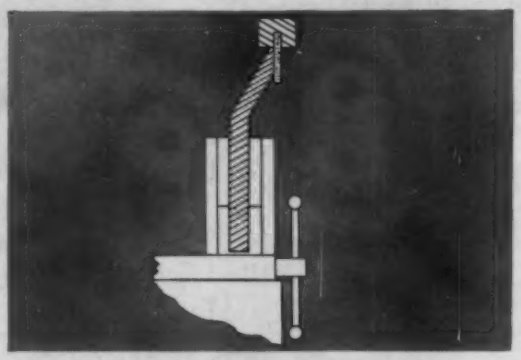


Figure 2—End view of die land honing operation.

Honing a set of die lands takes several hours. Therefore, it's a good idea to have a spare set available so that the extruder can operate while one set of die lands is being honed.

Only a precision machine shop should hone blown film dies. If your plant doesn't have one, send the dies out to an experienced shop for honing.

Special Treatment for Plated Dies

Chrome plated dies must be handled with extreme care. Honing will remove the chrome plate and is *not* recommended. If you can't smooth chrome plated dies by cleaning and polishing, send them out for replating by the die manufacturer or a shop experienced in such work.

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NEW BOOKS

PLASTICS TOOLING

Second Edition by Malcolm W. Riley (Reinhold, New York, pp. 210, $7.50)

After noting the similarity of title and table of contents, there is no further parallel between this and the first edition. Where the contents of the first volume swept the field imaginatively, the material in the second edition dispells imagery, gets down to the practical specifics.

Because of the diversification of plastic tooling techniques and applications, this is an area of technical processes that begs full-scoped description. No single volume can hope to be all inclusive, but the author, drawing heavily from his editorial experience, has compiled enough material to adequately fulfill the needs of many readers of this topic.

The major virtue of this book lies in the field of tabular and tabled data and only when the author becomes opinionated, which graciously is rare, does the technical merit evaporate.

As always with new processes the advantages of economy and fabrication-hours are freely expressed, but in the score of cost figures cited (two being duplicated on various pages) none were specifically illustrated to permit a correlative study.

Chaptered bibliographical references provide additional sources of study. Both the novice and the practitioner will find ample incorporated data, however.

James C. Engman
Milwaukee Plastics, Inc.

HANDBOOK OF CHEMISTRY AND PHYSICS

42nd Edition, Charles D. Hodgman Editor in Chief (The Chemical Rubber Co., Cleveland, Ohio, 1960. pp. 3481, $12.00)

This new edition, like the previous ones, has been revised and enlarged. The part devoted to plastics has been particularly improved upon. This section has twenty-nine classification categories: for example, trade names, forms, fabrication, electrical, mechanical and thermal properties, and chemical resistance. The book, divided into five parts, starts as in the past with the section on mathematics, (366 pp). The next sections deal with the following material; properties and physical constants of chemicals (over 1200 pp.); general chemical tables, including three for thermodynamic constants, hormones, vitamins and foods (over 600 pp.); data on heat, hygrometry, sound, electricity, calorimetry (800 pp.); quantities units, conversion tables, symbols, etc. (over 300 pp.). In all, 21 new tables have been added and 9 expanded and brought up to date.

Dr. Louis C. Barail
Barail Associates

RESINS, RUBBER, PLASTICS HANDBOOK

Norman G. Gaylord, Editor in Chief (Interscience Publishers, Inc., New York, N. Y., 1960, pp. 1567, $60.00)

This book is issued with the cooperation of the Institute of Polymer Research, Polytechnic Institute of Brooklyn, N. Y. It is a collection of abstracts of carefully selected papers dealing with the properties of resins, plastics and rubber. Most of the book is concerned with plastics. Section One contains general material. Section Two is devoted to the following plastics; ethylene and its polymers, styrenes, vinyls, acrylates and metacrylates, aldehydes, polyamides, polyesters, cellulosic plastics, silicones, polyurethanes and miscellaneous. Section Three deals with natural and synthetic rubbers and rubber derivatives. Graphs, tables and photographs are included. The authors have condensed thousands of pages into a useful and comprehensive encyclopedia. The handbook contains an author and a subject index.

Dr. Louis C. Barail
Barail Associates

MECHANICS OF SOLIDS AND FLUIDS

Robert R. Long (Prentice-Hall Inc., pp. 156, $9.00)

This text presents a useful addition to the literature. While primarily designed as a teaching aid to an engineering course in mechanics, it is an excellent reintroduction to the field for practicing engineers and scientists. The novel feature is the accomplished manner of introducing cartesian tensor notation in Chapter 1, and incorporating this theory of tensors into the definitions of stress, strain, and rate of strain in Chapters 2 and 3. Accompanying this satisfactory mathematical substructure is an excellent involvement of the concept of the mechanics of continuous media with the microscopic and molecular structure of real solids, liquids and gases. Chapter 4 expands the discussion of microstructure of crystalline (metals) and amorphous (polymers and glasses) solids and fluids (liquids and gases) and relates these structure considerations to their more prominent elastic, plastic, and viscous properties.

The remainder of this text is devoted to developing classical theory and problems in linear elasticity and Newtonian fluid mechanics. Chapters 5 and 6 treat the elastic properties of a generalized Hookian solid. Except for brief sections the discussion is confined to static response of isotropic media. The equations and principle problems of fluid statics and dynamics are presented in Chapters 7 and 8. These latter chapters maintain a good continuity with the introductory portion of the book. The stress, strain, and rate of strain tensors are implemented to provide concise and direct interrelations between dilational and distortional properties of fluids and solids.

The engineer or scientist concerned with the mechanical or rheological properties of polymers might desire an extension of this text to include the fundamentals of linear viscoelasticity. Within the designed scope of the volume the author has dealt with the mechanics of simple solids and fluids with unusual depth and clarity. The notes to references accompanying each chapter are a valuable adjunct to the discussion for those desiring additional information or viewpoints on the subjects discussed.

D. H. Kaelble
Minnesota Mining & Manufacturing Co.

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SPE JOURNAL

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Simplified Stress Analysis of Filament Reinforced Plastic Pressure Vessels

R. J. Brown, Jr., *Aerojet-General Corp.*

For the application engineer—a guide to the design of simple cylindrical and spherical vessels

Filament reinforced plastics differ from most materials of construction in that they combine two essentially different materials, fibers made of glass or metal, and synthetic resins into a composite material. An analogous material is reinforced concrete, but in reinforced plastics the filament reinforcing media provide the higher percentage of material and are usually more evenly distributed than the steel reinforcement is in concrete.

In the analysis of reinforced plastics it is necessary to assume that the two materials strain equally. This implies that a good bond exists between the fibers and the resin such that tensile and compressive deformations are identical. The shear stresses developed in the bond are relatively low, but in actual applications the flexibility or total elongation to rupture of the resin must be considered.

A second assumption necessary for a simplified analysis of filament-wound structures is that the materials obey Hooke's Law, i.e., stress is proportional to strain. This is essentially true for the glass filaments in that they behave almost elastically up to the rupture point as shown in *Figure 1*. The resin binders however are plastic materials and behave in a partially plastic and partially elastic manner as shown. By use of *Figure 2*, true resin stresses may be computed by use of the secant modulus at the strain level of the primary structure (filaments).

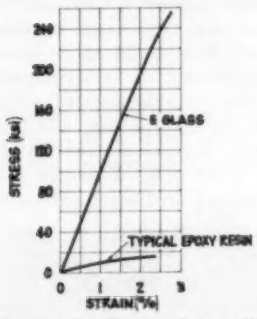

Figure 1. Typical tensile stress-strain curves for E Glass filaments and epoxy resins

Unidirectional Glass Filament Reinforced Plastic

As a first approach to simplified analysis of filament reinforced plastics, consider a single filament of a unidirectional laminate which is encased or covered by the plastic material (*Figure 3*). When the resin and filament are firmly bonded together the deformation under load is equal in both. When the stress strain characteristics of the resin and filament are known, the stresses developed in each for a given strain can be computed, and their combined action determined as follows:

$$S_y A = S_f A_f + S_r A_r \qquad (1)$$

where A = total cross sectional area
A_f = cross sectional area of fiber
A_r = cross sectional area of resin
S_y = mean unit stress based on cross sectional area perpendicular to the y axis
S_f = unit stress in fiber
S_r = unit stress in resin

If the moduli of elasticity are known, the following relationships can be determined:

$$S_y A = E\epsilon A = E_f \epsilon_f A_f + E_r \epsilon_r A_r \qquad (2)$$

where E = modulus of elasticity of composite
E_f = modulus of elasticity of filaments
E_r = secant modulus of elasticity of resin
ϵ = strain of composite
ϵ_f = strain of filaments
ϵ_r = strain of resin

Note: Since the resin does not exhibit a true modulus, the secant modulus corresponding to the degree of strain must be used. This can be approximated by assuming all forces are taken by the filaments and calculating the strain.

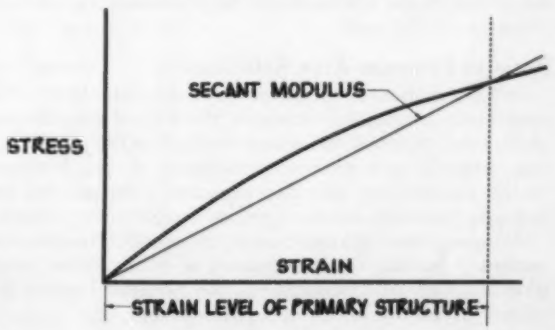

Figure 2. Secant modulus of plastic materials. With such curves, true resin stresses may be computed at the strain level of the filaments.

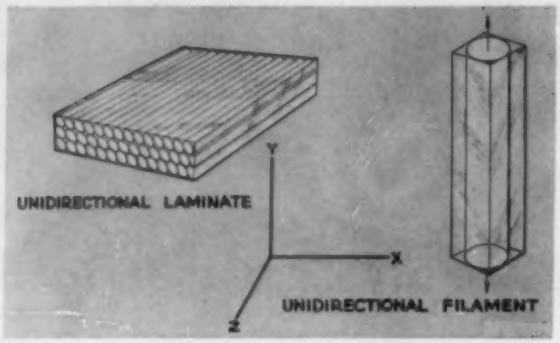

Figure 3. Unidirectional filament reinforced plastic

since $\epsilon = \epsilon_t = \epsilon_r$, $\epsilon = \frac{S_y}{E}$, $\epsilon_t = \frac{S_t}{E_t}$, and $\epsilon_r = \frac{S_r}{E_r}$

$$\frac{S_r}{S_t} = \frac{E_r}{E_t} \text{ or } S_r = \frac{E_r}{E_t} S_t \tag{3}$$

$$\text{and } EA = E_tA_t + E_rA_r \tag{4}$$

Substituting (2) in (1)

$$S_yA = S_t\left(A_t + \frac{E_r}{E_t} A_r\right) \tag{5}$$

In the x and z direction, the resin is predominate and the composite properties will very closely duplicate those of the resin binder.

Since E_r is very small relative to E_t, when considering glass or metallic filaments Equation (5) can be reduced to:

$$\text{for } E_r <<< E_t$$

$$S_yA_y = S_tA_t \text{ or } S_y = \frac{S_tA_t}{A_y} \tag{6}$$

The generalized equations for composites made up of a number of materials may be represented as follows:

$$SA = \sum_{i=1}^{i=n} S_iA_i \tag{7}$$

where S_i and A_i are the strength and cross sectional areas of each component.

Similarly, the overall modulus of elasticity and shear modulus G can be represented by the following equations:

$$EA = \sum_{i=1}^{i=n} E_iA_i \tag{8}$$

$$GA = \sum_{i=1}^{i=n} G_iA_i \tag{9}$$

These equations apply for loads applied normal to the cross section of the filaments. Properties of the laminate in the planes of the filaments are approximately equal to the properties of the resin.

Resin to Filament Area Relationship

In the application of filament reinforced plastics to a structure it is desirable to obtain the highest possible ratio of filaments to resin; the reason being that the plastic resin acts primarily as a binder contributing a small increment to the overall load carrying capacity, whereas, the high strength filaments are the primary load carrying material.

Assuming the filaments are of equal diameter, the optimum stacking or arrangement of filaments for a unidirectional filament laminate is the hexagonal packing as shown in *Figure 4*. In this arrangement, the maximum ratio of filaments to resin for equal sized filaments is obtained. The filaments in this situation make up 90.62 percent of the total volume or cross sectional area.

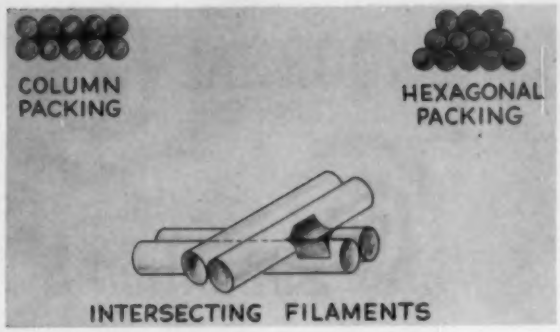

Figure 4. Resin-filament relationship. The hexagonal packing is the optimum

Actual fabrication of a filament-wound structure usually does not allow optimum orientation or packing of filaments. The necessity of locating the filaments in different directions results in local build-up and crossing of filaments. A diagram representing close spacing of crossing filaments and unidirectional filaments close spaced but not optimally located is shown in *Figure 4*. This "column packing" of unidirectional or intersecting filaments results in a 78.5 percent volume filament content.

Two approaches have been attempted to minimize the resin content of the composite by applying only a surface coating of resin to the filaments or basket weaving bonds of filaments. Both of these techniques as shown in *Figure 5* leave voids in the composite. A comprehensive three dimensional stress analysis indicates these voids might cause such problems as reduced compressive stress throughout the wall and high discontinuity stresses as a result of the "gap bridging" of filaments. These analyses and actual tests have shown the undesirability of this approach, particularly where repeated loading of the structure is involved. The basket weaving concept further increases the bulk modulus of the composite structure which is undesirable in certain applications.

Simplified Analysis of Cylindrical Pressure Vessels

Complete stress analyses of filament wound structures are very laborious. First, the load carrying capacity of each filament and its precise orientation individually within the structure must be determined. Even then since winding of continuous filaments is desired, local build-up or thickness variations result from the crossing of one complete winding over another introduce discontinuity stresses within the wall which may not be resolvable. Further, the final winding pattern for complex shapes may be dictated by the necessity to prevent slipping or filament displacement during the actual fabrication. A precise analysis involves an

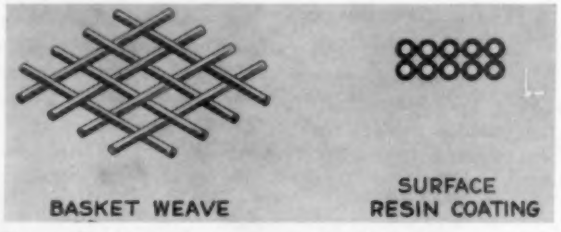

Figure 5. Minimized resin ratio. Voids shown might cause problems, such as reduced compressive stress and high discontinuity stresses

interaction technique which produces the proper stress-strain relationships within the plastic resin. This can only be accomplished by complete knowledge of the physical properties of the components involved.

An analysis is, however, available for first approximations of the structure's principal dimensions and weights. This analysis is accurate providing the structure can be fabricated by simple winding techniques. For pressure containers having single openings at either end, the weight and dimensional analysis has been shown to be correct.

The optimization of the cylindrical sections of pressure vessels is controlled by the requirements of longitudinal and circumferential strengths. Any of a number of winding patterns can be used to accomplish this. The shape of the head and size of opening are the governing factors in the final selection of the pattern. Final weights for all patterns will be the same, provided they meet the strength requirements in the two principal directions. Therefore, a simple pattern of longitudinal and hoop filaments may be assumed.

An assumed section of the cylinder will appear as shown in *Figure 6*. There are two layers or twice as many filaments oriented circumferentially to withstand the hoop stress as there are located longitudinally for the end loads. Consider now, an incremental area normal to the applied hoop stress which is one filament in width. Referring now to Equation (7), the mean unit stress in the hoop direction S_h can be represented as follows:

$$S_h A = \sum_{i=1}^{i=n} S_i A_i \tag{10}$$

$$S_h A = S_f A_{fh} + S_r A_r \tag{11}$$

where A_{fh} = cross section area of filaments acting in hoop direction
S_h = mean design hoop stress

Since S_r is small compared to the ultimate tensile strength of the filaments S_f, Equation (11) can be approximated by:

$$S_h = S_f \frac{A_{fh}}{A} \tag{12}$$

Also

$$A_{fh} = \frac{2}{3} AC$$

$$S_h = \frac{2}{3} CS_f \tag{13}$$

where C = volume percentage of filaments

Similarly from Equation (8), the hoop direction elastic modulus based upon total cross sectional area can be shown to be:

$$E_h = \frac{2}{3} CE_f \tag{14}$$

When the longitudinal parameters are substituted in Equations (8) and (9), it can be seen that the design stress and elastic modulus in this direction are approximately:

$$S_l = \frac{1}{3} CS_f \tag{15}$$

$$E_l = \frac{1}{3} CE_f \tag{16}$$

Simplified Analysis of Spherical Vessel

If an analysis similar to the above is considered for a sphere in which case the ideal filament distribution is such that equal strengths are obtained in all directions, the principal stresses will be equal and the allowable design stress is approximately:

$$S_s = \frac{1}{2} CS_f \tag{17}$$

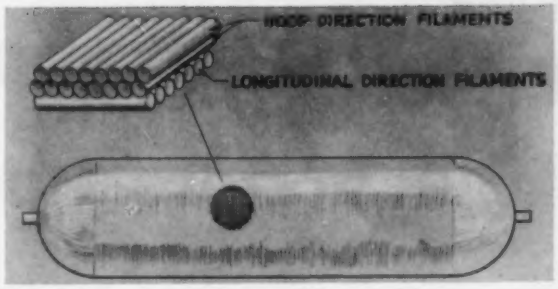

Figure 6. Pressure cylinder fiber orientation

$$E_s = \frac{1}{2} CE_f \tag{18}$$

where S_s = ultimate tensile stress in spherical wall
E_s = effective modulus of sphere

Comparison of Sphere and Cylinder

The interesting part of the above analysis is the relationship between the design ultimate tensile strength for a sphere, e.g., (16), and a cylinder, e.g., (13). In solving these two equations it can be seen:

$$S_h = \frac{4}{3} S_s \tag{19}$$

Further consideration of this relationship shows that based upon this ratio of design strengths, a spherical shape or a cylindrical shape to contain an equivalent volume of substance at a certain pressure will be of identical weight. This means that for filament-wound structures there is a constant relationship between weight of vessel-to-volume contained when the internal pressure is defined. This relationship is:

$$W/V = 3P/K$$

where

S_u = unidirectional laminate ultimate tensile strength (psi)
P = design pressure of vessel (psi)
K = S_u/ρ—strength density ratio
W/V = weight per unit volume (lb/in.^{3})
ρ = density of laminate (lb/in.^{3})

It should be noted that S_u and ρ apply to properties of a unidirectional laminate which includes the fiber and resin at the proper ratio.

In addition to the meaning that filament wound cylindrical vessels will be of equivalent weight to spherical vessels, the equation shows that two or more vessels can be used to contain a given volume and their total combined weight will be equivalent to that of a single vessel. This is a very significant advantage for filament-wound structures when fabrication limitations are reached. There are other configurations that produce the same results as cylinders and spheres.

Conclusions

This simplified analysis for filament-wound structures is not intended to be a complete procedure. Only the simplest configurations were considered. Those configurations which require multiple perforations or ports are much more complicated. The intent in this presentation is to familiarize the designer with the basic considerations for non-isotropic filament design analysis. In filament winding, a major consideration is the proper orientation of filaments which is compatible with the methods of fabrication.

Effect of Rubber Compositions *and* Plasticizers Upon Polyethylene*

Sydney Axelrod
U.S. Army Ordnance Corps, Picatinny Arsenal

Polyethylene is being used in ever increasing quantity as a packaging material for a vast variety of items from pickles in brine to molded rubber items. In addition to its use as a packaging material, polyethylene film is also being used in a number of other applications where it may be in contact with materials for extended periods of time. The suitability of polyethylene film for use in contact with these materials should be determined for each specific application.

In a previous paper (1) the effects of various rubber formulations and the ingredients commonly employed in such formulations upon polyethylene were reported. It was then shown that rubber compositions in general will not affect polyethylene. However, it was also shown that when rubber compositions contain ingredients, which by themselves attack polyethylene, the composition may also cause deterioration of the mechanical properties of polyethylene.

Only two ester-type plasticizers, i.e., tributyl citrate, and castor oil, had been investigated in the previous work. Since ester-type plasticizers are frequently used in rubber compositions it was subsequently decided to study several more plasticizers of this type. In addition, it was also decided to investigate the effects of a wider range of rubber polymers upon polyethylene. Finally, the effects of formulations containing these plasticizers and rubber polymers upon polyethylene were also to be determined. The results are reported below.

Before using polyethylene as a packaging material, it is wise to investigate any deteriorating effect that the material to be packaged has on the polyethylene. In this article the effect of rubber formulations are studied. Incompatible ester type plasticizers attacked polyethylene, especially at higher temperatures

Testing Procedures

The materials, whether plasticizers, rubber polymers, or rubber formulations, were stored in contact with polyethylene at 77°C (170°F). This temperature was chosen so that any deterioration of the plastic due to contact with the materials investigated would be accelerated and become apparent within a reasonable time. However, to determine the changes in the properties of polyethylene ascribable to the effects of storage at elevated temperature alone, control specimens of plastics were also stored at 77°C (170°F). In addition, polyethylene specimens were also stored alone at 25°C (77°F) to determine the effect due to aging. Finally, the original properties of the polyethylene before storage were also determined in order to provide a basis of comparison for the specimens stored in contact with the various chemicals and rubber formulations.

The tests chosen as being most indicative of deterioration of the polyethylene during storage were tensile strength and percent elongation at break. Retention of less than 85% of the normal tensile strength and less than 75% of the normal elongation of the polyethylene were considered to be an indication of serious deterioration of the plastic.

Sample Preparation

The rubber compounds were prepared according to the procedure standard in the rubber processing industry and were cured in 6 inch x 6 inch sheets. The rubber polymers and plasticizers that were stored in contact with the polyethylene were used "as received". The polyethylene tensile specimens were die-cut from film approximately 10 mils thick. The dimensions of the specimens were those of Specimen A shown in Federal Specification ZZ-R-601A. Ten tensile specimens were stored in contact with each material, plasticizer or rubber compound, in sealed glass containers at 77°C (170°F) for the length of time shown in the corresponding Tables. Ten tensile specimens were also stored in sealed bottles at 77°C (170°F) and at 25°C (77°F). The polyethylene specimens were subjected to the tensile test at a cross head speed of two inches per minute, using the Instron testing machine.

Calculations

The formula used in calculating the standard deviation of the tensile strength and percent elongation at break was:

$$S = \sqrt{\frac{\Sigma (Xi - \overline{X})^2}{n - 1}}$$

where: S is the sample standard deviation and measures the variation of the individual measurements
Xi is each unit value
$\overline{X}$ is the sample mean of the Xi
n is the sample size

Effects of Ester-Type Plasticizers

The loss in tensile strength (refer to *Table 1*), as compared with the original properties of polyethylene, was greater than 20% in every case, while the decrease in percent elongation was greater than 49% in every case. Only in the case of the composition containing polybutene in place of an ester-type plasticizer in contact with polyethylene was there a low loss in percent elongation. The results obtained with the esters were unexpected since the two esters discussed in the previous article (1) i.e., tributyl citrate and castor oil, had a negligible effect on the tensile strength of polyethylene under identical storage conditions.

* Low-density polyethylene

Table 1. Tensile Strength & Elongation of Polyethylene after Storage for Two Months at 77°C (170°F) with Plasticizers

Plasticizer	Tensile Strength (psi) Average	Standard Deviation	% Change	Elongation (%) Average	Standard Deviation	% Change
Glycol ester of vegetable oil fatty acid	1241	53	−27.0	154	43	−62.0
Tricresyl phosphate	1334	175	−21.5	253	112	−60.1
Tributoxy ethyl phosphate	1273	54	−25.1	204	67	−49.6
Dibutoxy ethyl phosphate	1272	127	−25.2	206	97	−49.1
Butyl carbitol adipate	1267	76	−25.5	188	83	−53.6
Polyethylene glycol di-2-ethyl hexoate	1266	60	−25.5	157	54	−61.2
Polybutene	1352	105	−20.5	357	42	−11.9
Original properties of polyethylene before storage	1700	204	—	405	83	—

Table 2. Rubber Formulations

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Butadiene-acrylonitrile (65:35) copolymer	100	100								
Polychloroprene			100							
Butadiene-styrene (76.5:23.5) copolymer				100	100					
Natural (smoked sheet)						100				
Isobutylene-isoprene (98:2) copolymer							100			100
Organic polysulfide rubber								100	100	
Stearic acid	1	1	0.5	1	1	2	3	1	1	3
Magnesium oxide			4							
Zinc oxide	5	5	5	5	5	5	5	0.5	0.5	5
Benzothiazyl disulfide	1.25	1.25		1.5	1.5					
Mercaptobenzothiazole						1.5	0.5			0.5
Di-o-tolylguanidine salt of dicatechol borate			1							
Tetramethyl thiuram disulfide							1			1
Phenyl-alpha-naphthylamine			1			1.5				
p-Quinonedioxime								1.5	1.5	
Sulfur	1.25	2		2	2	2.5	2			2
Butyl carbitol adipate								10		
Refined coal-tar distillate		20								
Vegetable oil fatty acid glycol ester	15									
Pine tar						5				
Saturated polymerized hydrocarbon					6					
Tributoxy ethyl phosphate	15			12	6		2			
Coumarone indene resin-medium hard		15			10					
Heliozone wax	2	2								
Light process oil			10							
Petrolatum			1							
Polybutene							2			
Fine thermal black	100					60				
Medium thermal black				40						
HAF black		50			50			60		
SRF black			50						60	
MPC black							50			50

Table 3. Effect of Rubber Formulations on Polyethylene During Storage at 77°C (170°F) for Two Months

Compound No.	TENSILE STRENGTH (psi) After one month Average	After one month Standard Deviation	After two months Average	After two months Standard Deviation	ELONGATION (%) After one month Average	After one month Standard Deviation	After two months Average	After two months Standard Deviation
1	1340	51	1350	39	86	11	78	22
2	1640	92	1330	153	434	29	321	81
3	1180	72	1080	53	295	58	244	48
4	1350	62	1430	146	286	29	312	53
5	1640	161	1660	193	411	62	418	70
6	1630	245	1650	162	391	92	425	45
7	1730	199	1590	220	446	71	416	85
8	1380	130	1440	146	297	45	307	83
9	—	—	1669	152	—	—	412	50
10	—	—	1748	79	—	—	445	40
25°C(77°) Control	1650	111	1730	173	383	43	431	65
77°C(170°F) Control	1690	223	1810	81	433	94	480	29

Accordingly, it is difficult at this time to make any generalizations about the effect of esters as a class on the properties of polyethylene. It is important, however, to recognize that there are esters which can cause serious degradation of the properties of polyethylene.

Rubber Compositions

In the case of the rubber formulations reported in *Table 2*, polyethylene was severely attacked (*Table 3 and 4*) by those compositions which contained at least 10 parts of those ester-type plasticizers which caused degradation of the plastic. For example, of the two butadiene-styrene copolymer compositions (compounds No. 4 and 5) only the one which contained 12 parts of tributoxy ethyl phosphate (compound No. 4) severely attacked the plastic while the composition containing 6 parts of the plasticizer (compound No. 5) had a minor effect on the properties of polyethylene.

One other significant fact emerges from further examination of the data obtained. The fact is that in no case can deterioration be shown to be due to the rubber polymer itself. Two rubber compounds tested were based on organic polysulfide rubber (compounds No. 8 and 9) but only compound No. 8, which contained 10 parts of butyl carbitol adipate per 100 parts of polymer, caused deterioration of polyethylene. Compound No. 9, which contained no plasticizer, had a minor effect on the properties of polyethylene.

Table 4. Effect of Contact with Rubber Formulations on the Properties of Polyethylene (% Change)

Compound No.	Tensile Strength One month	Tensile Strength Two months	Elongation One month	Elongation Two months
1	−21	−21	−77	−81
2	−4	−22	+7	−21
3	−31	−37	−27	−40
4	−21	−16	−29	−23
5	−4	−2	+1	+3
6	−4	−3	−3	+5
7	+2	−6	+10	+3
8	−19	−15	−27	−24
9	—	−2	—	+2
10	—	+3	—	+10

Conclusions

The mechanical properties of polyethylene are not seriously degraded by contact with rubber polymers. These properties may be affected however by ester-type plasticizers in rubber formulations. The extent of the degradation depends not only on the severity with which the plasticizer by itself attacks polyethylene, but is also dependent on the compatibility of the plasticizer with the rubber polymer in the composition. It is this compatibility which controls the amount of material which "bleeds" to the surface and it is the plasticizer "bleeding" to the surface that attacks the polyethylene.

It is apparent, therefore, that in rubber formulations in which ester-type plasticizers have only limited compatibility, consideration should be given to determining the effect of the particular rubber formulation on polyethylene especially if extended storage at elevated temperatures is likely to occur. No general investigation to determine the effects of any specific compositions upon polyethylene is feasible because of the many variations possible in rubber compounds.

It should also be kept in mind that these results may be applicable by analogy to plastic compounds (e.g. thermoplastics) containing ester-type plasticizers. This is especially of interest in Ordnance applications where storage or use of thermoplastics packaged or stored in contact with polyethylene at elevated temperatures is required. At these elevated temperatures, plasticizers have been known, in some instances, to exude or "bleed" to the surface of the fabricated item to a greater or lesser extent. Therefore, the effects of a specific plastic composition upon polyethylene should be investigated, especially if extended storage or elevated temperature usage in contact with polyethylene is involved.

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Acknowledgments

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Plastisol Distribution in Rotational Casting

Rotational casting is fast becoming an important commercial method of converting vinyl dispersion resins, in the form of plastisols, into hollow moldings. The process consists of simultaneously heating and rotating a predetermined charge of vinyl plastisol, in a closed mold, about two axes approximately perpendicular to each other. The rotation distributes the liquid plastisol on the inner face of the mold where it is gelled by heat. Upon subsequent cooling and opening of the mold the molded article is removed. This article describes laboratory studies which point the way to optimum plastisol formulation and scale-up to production equipment

L. A. McKenna

Union Carbide Plastics Company

At the present time, there are about 100 companies engaged in rotocasting in this country, with many of these having more than one rotational casting unit in operation. Although most of the articles fabricated by this technique have been in the doll or novelty fields, actual production of several industrial items (such as automotive arm rests and sun visors) is underway. The outstanding physical properties of plastisols combined with the diversity of design possibilities in forming by rotational casting are certain to attract the manufacture of many more items to this molding technique. Total dispersion resin consumption in 1959 is estimated at 90-100 millions pounds of which 54 million pounds are listed under slush and elastomeric molding (1). If additional industrial items could be added to the toys and novelties being produced by rotocasting, this market could easily become a large outlet for vinyl resins and related chemicals.

One of the major considerations in any rotocasting operation, and a consideration that will assume even more importance in the fabrication of industrial items, is the uniformity of wall thickness in the part produced. Considerable work has been performed on evaluating the effects of certain variables on uniformity—variables that are related to the rheological properties of the plastisol and to the rotocasting process itself. In addition, the flow process that takes place inside a rotating mold was studied by means of simulated and actual rotocasting experiments.

Experimental

The variables studied were: plastisol viscosity, plastisol gel temperature, mold turnover speed, and mold geometry. These variables of rotational casting were evaluated on both laboratory and production equipment. The laboratory model was a single spindle Akron Presform machine (*Figure 1*). The findings derived from experiments on the laboratory machine were subsequently applied to an E. B. Blue Model 200 production rotocasting oven (*Figure 2*).

Five molds of different shapes were used in order to determine the effect of mold geometry on plastisol distribution (*Figure 3*). The box, horse head, and doll head molds were nickel-plated copper electroforms. The ball mold was an aluminum casting and the cushion mold was constructed from ¼-inch aluminum plate stock. The dimensions of each mold and the charges used to get a wall thickness of about 1/16-inch are shown in *Table 1*.

Seven separate plastisol formulations were developed with concern only for their viscosity and gelation temperature *Table* 2. They were formulated to be fast, moderate, and slow gelling at each of two viscosity levels. The viscosity levels selected, 25 and 65 poises at 20 RPM, are

Figure 1. Interior view of Akron Presform Machine, showing spindle inclined at an angle of 15°

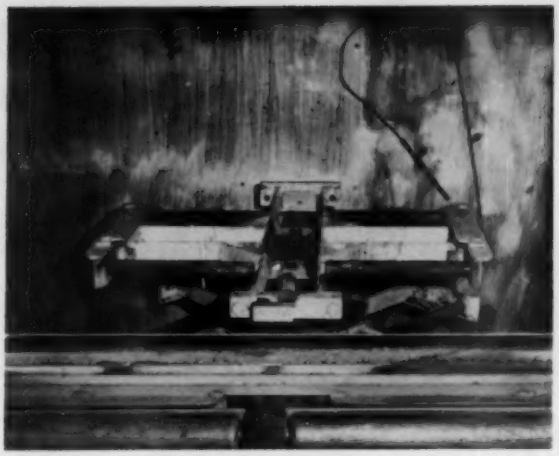

Figure 2. Interior view of E. B. Blue Model 200 Oven, showing two axes of rotation at right angles to each other

Table 1. Charges Used with Various Molds

Mold	Dimensions	Plastisol Charge
Cushion	15" x 13" x 2½"	773 grams
Box	10" x 7" x 6"	700 grams
Horse Head	7½" high, elliptical base 8" x 6"	600 grams
Doll Head	5" high, 4½" diameter	150 grams
Ball	2⅜" diameter	25 grams

considered to be close to the extremes that might be found in commercial operations. The gel curves of the low and high viscosity plastisols are in close agreement when superimposed upon one another; such curves are typical of commercially available plastisols.

Viscosity and gel curve measurements were made on the same day that the plastisols were rotocast thereby eliminating any effects due to aging. Viscosity was measured with a Brookfield Model RVF Viscometer, number six spindle, at 2 and 20 RPM. Gel curves were determined with a modified Brabender Recording Viscosimeter (2). This is basically a donut-shaped sample holder that is capable of being heated and rotated. A combination probe-thermocouple is inserted into the sample and the torque applied to the probe by the sample rotating at 36.5 RPM is measured by a strain gauge. A plot of torque (in arbitrary units) versus temperature yields the sample's gel curve.

Figure 3. Five molds used in the experiments

By controlling electrical input to the heating elements, all plastisols were tested at an average heating rate (start to finish of run) of 3.3± 0.4°C per minute. Although this is considerably lower than the heating rate observed in the horse head mold during rotocasting in a 600°F oven (10.9°C per minute), experimental difficulties precluded the use of a faster rate. Since there is evidence that the position of the gel curve with reference to the temperature axis is independent of heating rate and since gel rate differences between samples would be the same at any constant heating rate, the difference between heating rates in the casting operation and the gel curve determination is

Table 2. Characterization of Plastisols by Gel Temperature and Viscosity

		Plastisol Number						
		1	2	3	4	5	6	7
Gel Temp.[1]		Low	Mod.	High	Low	Mod.	High	Mod.
Viscosity[2]	Low	35/26	40/24	75/22	—	—	—	—
	High	—	—	—	100/70	95/63	100/73	90/68

[1] Low gel temp. = 60°C
Mod. gel temp. = 80°C
High gel temp. = 100°C
[2] Viscosities are the Brookfield viscosities, #6 spindle, at 2/20 RPM.

not regarded as serious. The gel curves of all plastisols studied are shown in *Figures 4, 5, 6 and 7*. Gelation temperature is arbitrarily defined as the temperature at which the torque developed by the plastisol on the ascending portion of the curve is equal to 2 scale units.

Castings were rated as to the uniformity of wall thickness by examining their interior face. Ratings, ranging from 1 to 8, were arbitrarily selected. A rating of 1 is equivalent to a perfectly smooth interior while 8 represents an uneven surface due to drips, bumps, and ridges. All ratings in a given mold were cross-checked against one another and spot-checks were made between molds so as to insure consistency of the ratings.

Background

Much has been written on the process of plastisol gelation and fusion. (3-6) The rotational casting operation has likewise been widely covered (7-14). Nevertheless, there still exists considerable confusion surrounding the process. The miscomprehensions are mainly centered on two areas. First, it is a natural tendency to regard rotational and slush casting as being equal in their rheological requirements. This notion leads to the erroneous conclusion that the two operations will require the same rheological properties of a plastisol. Secondly, the role of centrifugal force in the rotational casting process has never been clearly defined. Presently, there exist two schools of thought on this subject—one in which centrifugal force plays a definite part and the other where it exerts no effect at all.

In order to resolve these difficulties and obtain a better insight of the rheology of the process let us start by comparing the performance of two plastisols of approximately equal gelation temperature and whose Brookfield viscosities were as follow:

BROOKFIELD VISCOSITY	PLASTISOL A	PLASTISOL B
2 RPM	880 Poise	250 Poise
20 RPM	138	70

- Using the cushion mold it was found that Plastisol A would not fill out the mold at 3 or 10 RPM turnover speed whereas Plastisol B molded without difficulty.
- In previously conducted experiments, it was established that the limit of moldable viscosity for this mold is about 100 poise. This is to say, that if the viscosity of a plastisol at 20 RPM Brookfield is greater than 100 poise, the plastisol will not fill out the cushion mold.
- Since Plastisol B filled out the mold satisfactorily, its viscosity during casting must have been 100 poise or less.
- Looking at the data above, it can be seen that the viscosity of Plastisol B would drop below 100 poise at a shear rate greater than that developed by the Brookfield at 2 RPM.
- Therefore, the shear rate of the rotocasting process is higher than the very low rate associated with the Brookfield at 2 RPM.

The behavior of plastisol formulations 5 and 7 can be studied to estimate the order of magnitude of the shear rate encountered in rotocasting. Plastisols 5 and 7 have almost identical viscosities at the low shear rates of the Brookfield viscometer (*Table 2*). Yet, Plastisol 7 did not flow enough

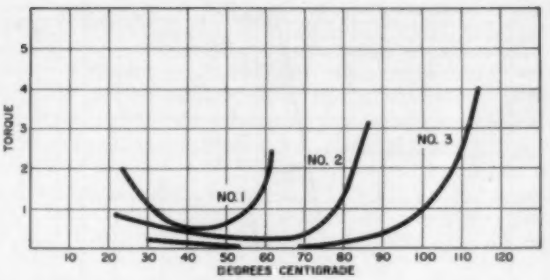

Figure 4. Gelation curves of low viscosity samples

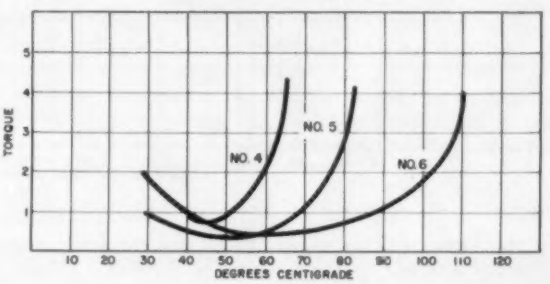

Figure 5. Gelation curves of high viscosity samples

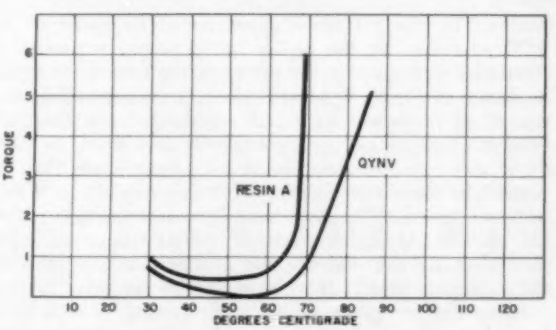

Figure 6. Gelation curves of different resins

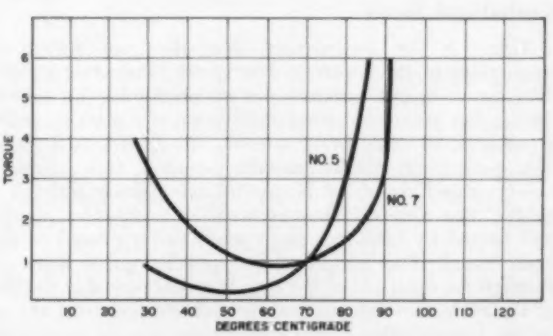

Figure 7. Gelation curves of pseudoplastic and dilatant plastisols. Note high initial torque of No. 7

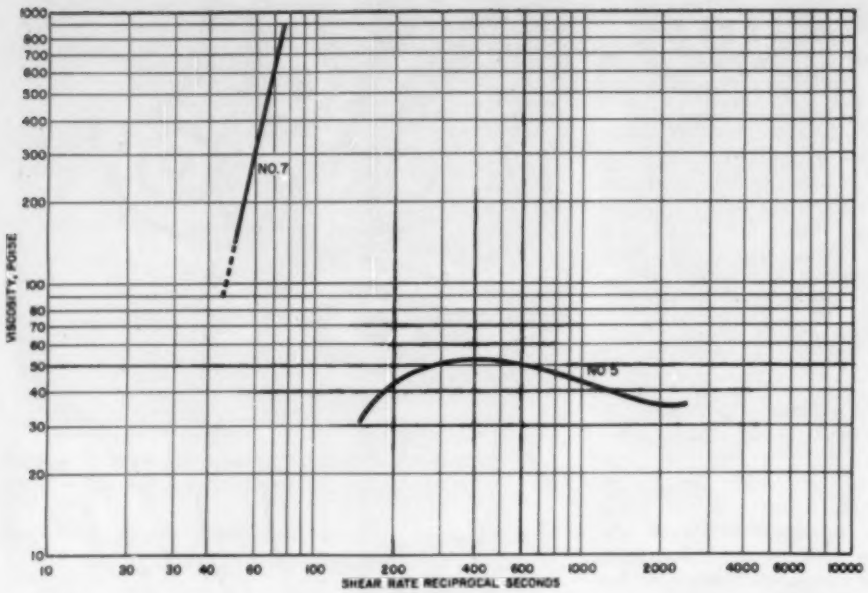

Figure 8. Flow curves of plastisols; viscosity vs shear rate. No. 7 is extrapolated to 100 poise, which corresponds to a shear rate of 46 reciprocal seconds

at the higher casting speeds to fill out the cushion mold whereas sufficient flow was evident in Plastisol 5 (*Table 3*). Therefore, the viscosity of Plastisol 7 at these speeds must have been greater than the 100 poise maximum moldable viscosity previously mentioned as necessary for complete mold-fill-out. The flow curves in *Figure 8* show that this is possible as Plastisol 7 becomes extremely dilatant at a shear rate of only 50 reciprocal seconds. (This dilatancy is also detected by the gel curve apparatus at its speed of 36.5 RPM as shown by the higher initial torque registered for Plastisol 7 in *Figure 7*). By extrapolating back to 100 poise, as shown in *Figure 8* (dotted line), a corresponding shear rate of 46 reciprocal seconds is obtained. Since Plastisol 7 filled out the cushion mold completely at 4 RPM, its viscosity at this turnover speed must have been lower than 100 poise. The shear rate developed in this plastisol at 4 RPM turnover speed, then, must have been less than 46 reciprocal seconds. At higher turnover speeds where incomplete fill-out occurs, the viscosity was greater than 100 poise and the shear rate greater than 46 reciprocal seconds.

From the foregoing remarks, rotocasting is seen to be, basically, a low shear rate process. The shear rates developed are higher than those associated with slush molding. At the faster turnover speeds, these shear rates become high enough to cause flow problems with very dilatant plastisols.

Centrifugal Force

There is the controversy over the part centrifugal force plays in the relatively low speed rotocasting process. The answer to this question was obtained with the aid of a device that permitted visual observation of a plastisol undergoing gelation while being rotated. The apparatus consisted of a quart paint can horizontally mounted, and capable of being rotated about the horizontal axis passing through its center. The can was charged with an amount of plastisol and heated by infra-red lamps while being rotated at constant speed. The sample throughout its gel was viewed through the open end of the can. It was observed at the start of the cycle that the plastisol formed "strings" from the top to the bottom sides of the can. As the sample heated and decreased in viscosity, "stringing" stopped and a puddle of plastisol formed. This puddle was not greatly displaced from the lower-most point in the can even at speeds of 10 RPM. With continued heating, viscosity began to increase and "stringing" resumed. Low viscosity plastisols did not begin this second-stage "stringing" until the puddle had almost disappeared by distributing itself on the walls of the can. With high viscosity samples, the second-stage "stringing" resulted in ridges and drips which gelled in place. From these experiments, it can be understood why low viscosity favors uniform distribution. In addition the experiments show that centrifugal force plays only a minor role in rotocasting. Calculations based on a test run follow:

Centrifugal Force in Rotating Can

$$\text{Force} = \frac{WV^2}{gr}$$

Where:

W = weight of body
V = velocity
g = acceleration due to gravity
r = radius

$$V = \text{angular speed} \times \text{radius}$$

$$= \frac{10 \text{ rev./min.} \times 2\pi \text{ radians/rev.} \times 2.0625 \text{ in.}}{60 \text{ sec./min.}}$$

$$= 2.16 \text{ in./sec.}$$

$$\text{Force} = \frac{.1984 \text{ lbs.}}{384 \text{ in./sec.}^2} \times \frac{(2.16 \text{ in./sec.})^2}{2.0625}$$

$$= 0.0012 \text{ pounds}$$

The equation above applies to bodies moving in a circular path. Thus, 0.0012 pounds would be the centrifugal force exerted by 0.19 pounds of plastisol moving around the periphery of the can as a puddle. Since the plastisol puddle remained at the lower most point in the can, the centrifugal force it exerted at 10 RPM was even less than 0.0012 pounds.

The conception based upon the distribution of the plastisol on the walls of the mold as they are brought under the resin puddle by the complex rotating action is often referred to as the "puddle approach" (7,9). The foregoing results lend experimental support to the puddle theory, but such support

Table 3. Uniformity of Pseudoplastic vs Dilatant Plastisols at Approximately Equal Viscosities and Gel Temperatures

Mold	RPM	Pseudoplastic Plastisol #5[1]	Dilatant Plastisol #7[1]
Cushion	4	5	8
	6	3	5—Incomplete
	12	1	2—Incomplete
Doll Head	4	7	7
	6	5	5
	12	2	2
Horse Head	4	5	8
	6	4	7
	12	2	5
Box	4	7	8
	6	5	7
	12	2	6

[1] A rating of 1 is equivalent to a perfectly smooth interior mold surface while 8 represents an uneven surface due to drips, bumps, and ridges.

is limited only to small or spherical molds where a puddle can form.

Large Molds—The "puddle theory" does not apply when large or rectangular shaped molds are being used. Observations on plastisols that had been rotated only a few times in the box mold revealed that the plastisol flowed in an approximate triangular path. The triangle became increasingly longer and broader with each rotation. The mold was eventually filled out in this manner. Thus, with large or rectangular shaped cavities, mold fill-out becomes a problem since the plastisol must have the opportunity to flow across long surfaces. It follows that low plastisol viscosity and low turn-over speeds would help provide this opportunity. Experience with a large flat mold (21" x 21" x 1.5") revealed that such conditions were needed for complete fill-out. *Tables 3 and 4* present performance ratings for the large cushion mold at the higher turnover speeds. The limit of moldable viscosities for the 21-inch mold was about 8,000 centipoise. By way of contrast, plastisols as viscous as 30,000 centipoise produced excellent results in the 2⅜-inch ball mold. Fill-out can be assured by rotation before heating in some equipment, but this technique ignores the source of the trouble and leads to increased cycle times. Additional evidence showing the importance of low viscosity in obtaining fill-out in large flat molds can be found by examining the performance ratings.

With the foregoing analysis of the rotocasting process and the distinction between mold fill-out and uniformity of wall thickness in mind, let us proceed to examine the factors that effect uniformity in rotational casting.

Results

Rating of the various castings made on the laboratory model Akron Presform Machine using 4:1 speed ratio are shown in *Table 4* and *Figures 9, 10, and 11*. The curves in *Figures 9 and 10* were obtained by plotting the "average" values of all castings in a given gel temperature group. These curves show the effects of turnover speed and gel temperature. The curves in *Figure 11* were obtained by plotting the grand average of all castings at each viscosity

Table 4. Summary of Data

Gel Temp.	Low Viscosity[1] Rating at 4 RPM	Rating at 6 RPM	Rating at 12 RPM	Mold	High Viscosity[1] Rating at 4 RPM	Rating at 6 RPM	Rating at 12 RPM
Low	5	4	2	Cushion	7	5	2[2]
	7	4	2	Doll Head	8	5	3
	7	5	4	Horse Head	8	7	5
	—	—	—	Box	8	7	5
	5	4	3	Ball	—	—	—
	6	4.25	2.75	Avg.	7.75	6	3.75
Moderate	3	5	1.5	Cushion	5	3	1
	3	2	1	Doll Head	7	5	2
	4	2	1	Horse Head	5	4	2
	—	—	—	Box	7	5	2
	4	3	2	Ball	5	3	2
	3.5	3	1.375	Avg.	5.8	4	1.8
High	8	6	6	Cushion	6	4	6
	4	2	2	Doll Head	5	1	1
	8	8	5	Horse Head	6	5	4
	—	—	—	Box	7	6	6
	5	4	3	Ball	—	—	—
	6.25	5	4	Avg.	6	4	4.25
Grand Total	63	49	32.5		84	60	41
Grand Avg.	5.25	4.08	2.71		6.46	4.62	3.16

[1] A rating of 1 is equivalent to a perfectly smooth interior mold surface while 8 represents an uneven surface due to drips, bumps, and ridges.
[2] —Incomplete Fill-Out of Mold.

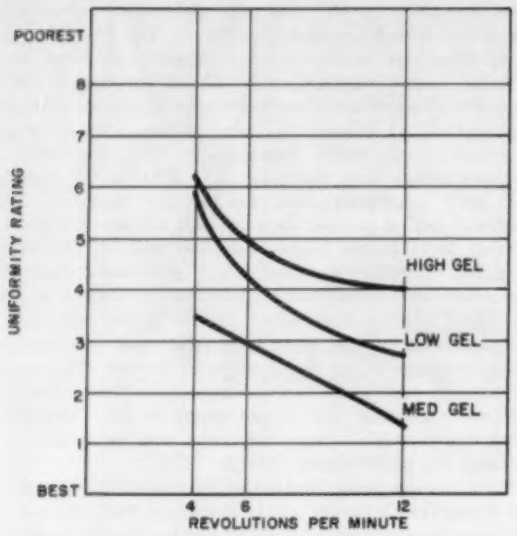

Figure 9. Effect of turnover speed and gel temperature on low viscosity plastisol

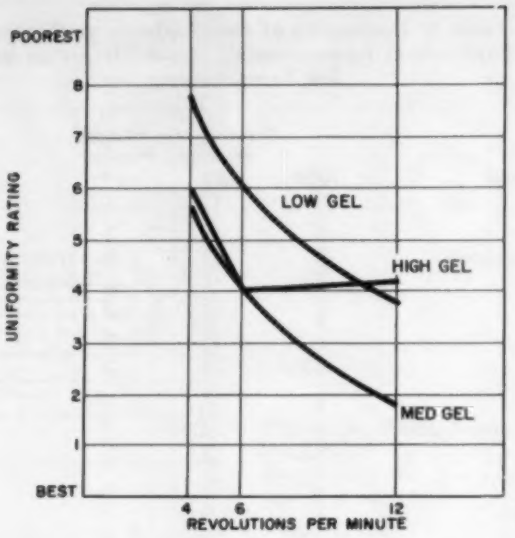

Figure 10. Effect of turnover speed and gel temperature on high viscosity plastisol

level. These curves show the effect of viscosity and, again, turnover speed.

Effect of Turnover Speed—The uniformity of plastisol distribution is distinctly improved as turnover speed increases. Plastisols with high gelation temperatures were somewhat insensitive to speed changes except in the spherical doll head mold.

The beneficial effect of higher speeds can be attributed, in part, to the pseudoplastic nature of these plastisols in the shear rate region involved. As the shear rate is increased slightly by a higher turnover speed, the plastisol's viscosity drops and flow is enhanced.

Effect of Gel Temperature—The most uniform castings were obtained with plastisols of moderate gel temperature; plastisols of high viscosity were less sensitive to gel temperature changes than their low viscosity counterparts. At the low viscosity level, the plastisols with high gel temperatures were consistently inferior at all speeds. *Table 5 and Figure 6* which compare Resin QYNV and another commercial resin (Resin A), show that small gel temperature differences between resins cannot be detected in rotocasting performance.

Figure 7 presents the two extreme forms that a gel curve determined by the modified Brabender Recording Viscometer can take. The dilatancy of plastisol 7 is detected by the apparatus at the speed of 36.5 RPM, whereas this flow behavior is not evident from the Brookfield Viscosities of the same plastisol. *Table 3* which shows a comparison of pseudoplastic and dilatant plastisols of approximately equal viscosities and gel temperature clearly reveals that the dilatant plastisol was inferior to its pseudoplastic counterpart with regard to both thickness uniformity and mold fill-out.

Effect of Viscosity—Viscosity changes, within normally encountered ranges, were surprisingly small. However, it should be understood that a uniform casting was given a

Table 5. Uniformity with Different Resins[1]

	Resin QYNV	Resin A (A standard commercial resin)
Brookfield Visc., Poise, 2/20	45/34	65/44
Gel Temperature (Figure 6) °C	74	66
	RATINGS	
Horse Head at 12 RPM[2]	1	1
Doll Head at 12 RPM	1	1
Cushion at 12 RPM	1	1.5
Ball at 4 RPM	4	4
Ball at 6 RPM	3	3
Ball at 12 RPM	2	2

[1] In low viscosity, moderate gel temperature formula No. 2.
[2] A rating of 1 is equivalent to a perfectly smooth interior mold surface while 8 represents an uneven surface due to drips, bumps, and ridges.

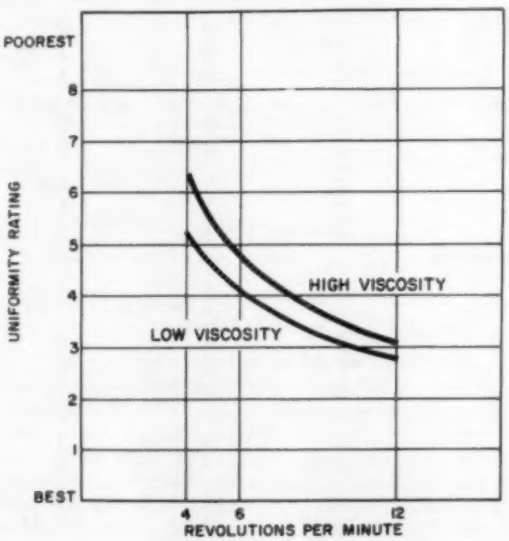

Figure 11. Effect of turnover speed and viscosity on plastisol distribution

Table 6. Correlation Between Laboratory and Production Equipment[1]

Turnover Speed	4		6		12		18	
Viscosity	Low	High	Low	High	Low	High	Low	High
Machine:								
Laboratory	4	5	3	4	2	3	—	—
Production	—	—	4	5	Top-1 Bottom-3	Top-1 Bottom-3	Top-1 Bottom-7	Top-1 Bottom-8

[1] Rotocasting performed at a 4:1 speed ratio with plastisols of moderate gel temperatures. The low viscosity sample was 30 to 24 poise at 2 to 20 RPM and the high viscosity sample was 65 to 60 poise at 2 to 20 RPM. The cushion mold was used for this test.

good (low) rating even if the mold was not filled out completely. While uniformity was generally better at the lower viscosity (*Figure 11*), this effect was minimized at the higher speeds, particularly with plastisols of moderate gel temperatures. High viscosity actually favored uniform thickness with plastisols having a high gel temperature.

Effect of Mold Geometry—This subject has already been discussed in greater detail under the "Large Molds" section. Uniformity of wall thickness was independent of mold geometry in this study; what was good in one mold was as good in the other molds used, with but one exception. The spherical doll-head mold seemed particularly suited to the high viscosity, high gel temperature plastisol. Of course, mold irregularities, sharp protrusions, or recessions shielded from heat oppose plastisol build-up and are not considered here.

Correlation of Results on Production Equipment

High and low viscosity plastisols of moderate gel temperature were rotocast in the cushion mold in both the pilot and production machines. The results of these tests are shown in *Table 6*. Direct comparison of the two machines over a wide range of speeds was not possible, but the trend towards improved uniformity at the higher speeds was observed on the production unit. At the higher speeds in the production machine, a marked difference in uniformity existed between the top and bottom sides of the casting. The cause of this phenomenon is not known at this time.

Figure 1 showing the laboratory Akron Presform machine and *Figure 2* which shows the E.B. Blue Model 200 oven reveal a major difference between the two machines used. In the laboratory machine, the spindle to which the mold is attached is inclined at an angle of 15 degrees and the two axes of rotation are at an angle of 75 degrees to each other. Their point of intersection is far removed from the mold. This causes the mold to describe a cone-shaped path as it is rotated. In the production machine, the two axes of rotation are at right angles to each other and these axes intersect directly under the mold. In this case, the mold travels a circular path as it is rotated. Despite these differences, the performance of the two machines correlates to a surprising extent.

Conclusion

The rotocasting operation is a low shear rate process in which centrifugal force plays only a minor role. Large or flat molds present a different situation than small or spherical molds. The former present fill-out problems which are not usually met in the latter. Laboratory results show that, for small molds, optimum uniformity will be obtained with low viscosity, pseudoplastic plastisols of moderate gel temperature and at high turnover speeds. Scale up of these findings to production equipment has been successful.

Acknowledgment

The author wishes to acknowledge with gratitude the assistance of Mr. F. Dutka, Jr., during the course of his work.

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11. U.S. 2,629,134 Sun Rubber Co.
12. U.S. 2,681,472 Vinyl Cast, Inc.
13. U.S. 2,881,476 M. Page.
14. U.S. 2,893,057 Sun Rubber Co.

—— ■ ——

Errata

Volume 16, No. 3, March, 1960, "Cure of Molded Melamine Resin and its Significance for Properties" by H. P. Wohnseidler and R. A. Tiley.

***Figure 10* should be marked *Figure 11* and bear the caption "Total shrinkage and cure." *Figure 11* should be marked *Figure 10* and bear the caption "Aging shrinkage and cure". Ordinate values should read *15, 10* and *5* rather than *20, 15* and *10* respectively.**

MICROGRAPHIC EXAMINATION OF POLY (VINYL CHLORIDE) TUBES

A. Huber, D. Whitwham,
O. Diner, and J. Herenguel
Trefileries et Laminoirs du Havre
Antony, France

A useful technique in studying defects in extruded tubing

Photographs of PVC tubes after about 10 minutes attack by methylene chlorid

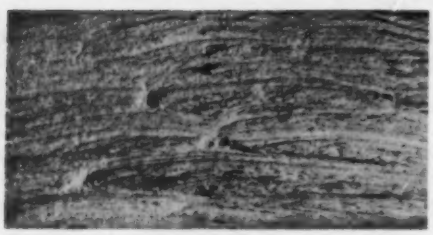

Figure 1. General appearance of a P.V.C. tube after extrusion

The application of classical techniques of metallography has been applied to the study of poly (vinyl chloride) tubes. The study was made to attempt to correlate accidental fragility of certain portions of the tubes to fabricating conditions.

Surface preparation involved the polishing method used for metals, but the finishing with alumina has to be reduced to a minimum to avoid incrustation of alumina grains in the PVC. Also, in an attempt to obtain perfectly reproducible structures for study, the action of various solvents on PVC was tried. For example: alcohols, acetone, dioxane, cyclohexanone, trichloroethylene, formic acid, tetrahydrofuran, and methylene chloride. Only methylene chloride has revealed structures and textures which are perfectly reproducible.

The microphotographs presented on this page give a detailed description of what can be seen when PVC tubes are examined under a microscope with reflected light.

This method may be useful in furnishing information on the mechanism of flow in extruders, and on the presence of scrap, which would be difficult to find by other techniques. Further extension of this micrographic technique would involve statistical correlation of the observed heterogeneities with the mechanical behavior of the material examined.

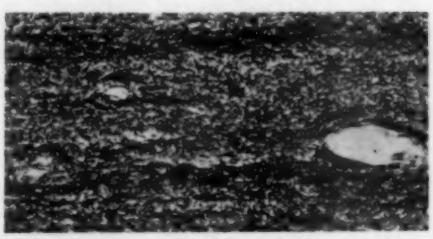

Figure 2. Clear Heterogeneities show on surface. Clear zones are not made of wax, as proven by microhardness measurements. Primarily fragments are of PVC scrap

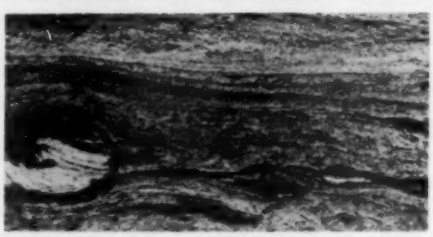

Figure 3. Heterogeneity is slightly elongated in the direction of flow —X = 13

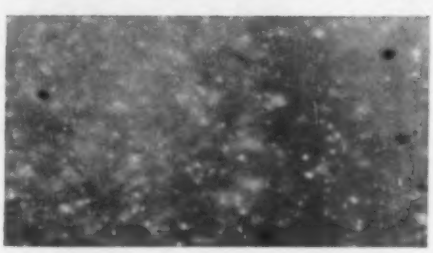

Figure 4. Typical distribution of oxide (and colorant) in an orange tube X = 820

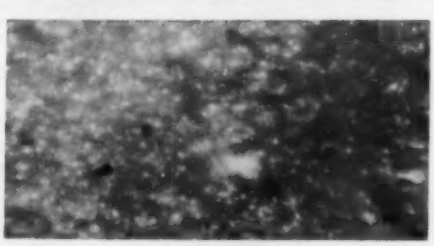

Figure 5. Typical distribution of the particles of oxide (and colorant) in a blue tube —X = 820

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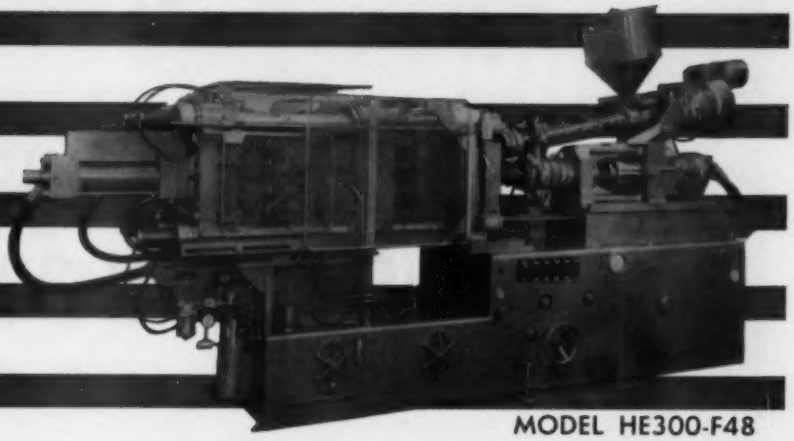
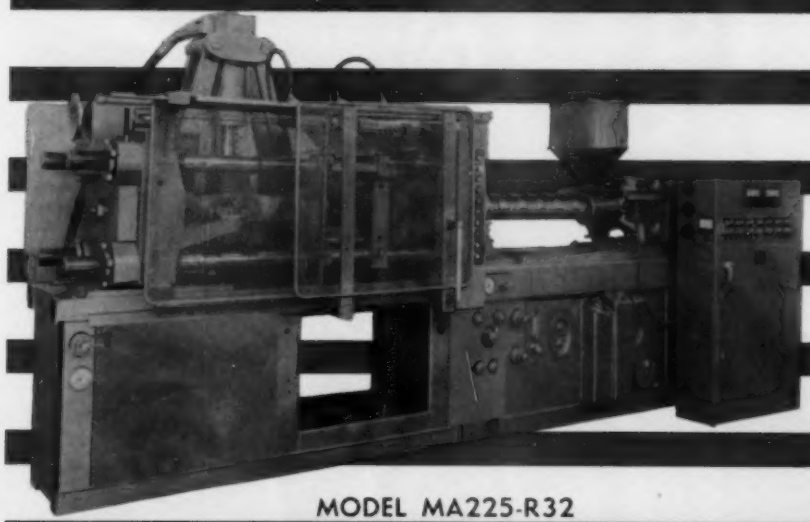


MODEL HE300-F48



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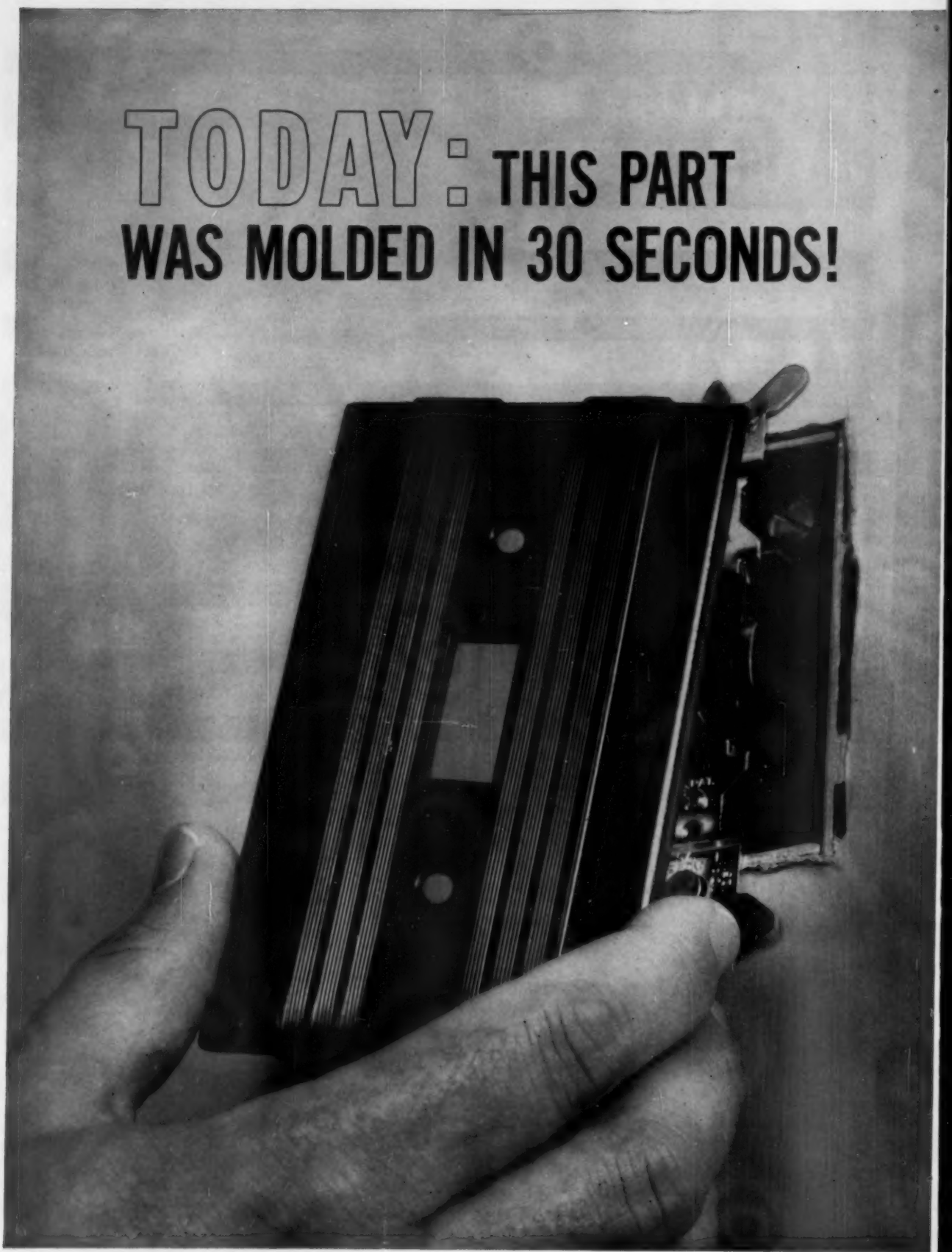
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GENERAL PERFORMANCE SPECIFICATIONS
Models 176 and 177

Bridge	Four active arms
Non-linearity	Less than 1.0% of full scale (2.0% for 12" length)
Hysteresis	Less than 0.5% of full scale (1.0% for 12" length)
Repeatability	Better than 0.2% of full scale
Resolution	Infinite
Zero Pressure Output	Model 176 ± 2.0% F.S. maximum Model 177 ± 15.0% F.S. maximum
Thread Temperature **Cooled** **Uncooled**	 750°F. maximum 300°F. maximum
Thermal Zero Shift (Based upon thread temp.)	Less than 0.02%/°F. (0.04%/°F. for 12" length)
Thermal Sensitivity Shift (Based upon thread temp.)	Less than 0.01%/°F. (0.02%/°F. for 12" length)
Impedance	Output 350 ohms ± 10% Input Model 176 350 ohms ± 1% Model 177 350 ohms ± 10%
Lengths (Dimension "B")	2", 4" and 6" in all pressure ranges. 12" in 3,000, 5,000 and 10,000 psi ranges only.
Maximum Pressure	150% of rating
Recommended Excitation	10 volts DC or AC, 17 volts maximum
Cooling Air	1 cfm at 25 psig, clean, dry air
Material	Body and diaphragm are 17—7 PH stainless steel
Installation	50 inch-pounds torque maximum and back off 1/4 turn for thermal expansion. Graphite-based grease or molykote on threads is recommended.

7877

How SPE Recognizes Distinction in Plastics Science and Engineering

Frank W. Reinhart,
Chairman, Committee on
Distinguished and Honorary Membership,
SPE Past Presidents Advisory Board

Plastics science and engineering have reached a level of development and maturity in which certain individuals are outstanding in this branch of the physical sciences among many high quality scientists and engineers. These outstanding individuals deserve recognition by their fellow workers. because SPE is concerned principally with plastics science and engineering and because it is a society of individuals, recognition of these outstanding individuals is a responsibility of SPE. Means are provided in the Constitution and By-laws for meeting this responsibility. We now need action to implement these provisions.

The SPE Constitution provides six classes or grades of members, namely: Senior, Associate, Junior, Student, Distinguished, and Honorary.

Article 1, Section C-11 states that:

"A Distinguished Member, at the time of his election, shall be a member in good standing who has attained professional eminence in the plastics field, who has made a significant contribution to the plastics industry, and who has given outstanding devotion and service to the Society; or who has served the Society as President."

Do you know anyone who meets fully the three qualifications required and whom you believe should be a Distinguished Member of SPE?

Article 1, Section C-12 states: "An Honorary Member shall have been a non-member who, by virtue of outstanding achievement or professional eminence, may be deemed worthy of this status." Do you know anyone whom you believe has the stature to be and should be an Honorary Member of SPE?

Furthermore, C-19 states:

"Distinguished Members shall be exempt from payment of dues. Honorary Members shall be exempt from payment of initiation fees or dues."

By-law B-9 states:

"The Past Presidents Advisory Board shall consider and act on all nominations for the classes of Distinguished Member and Honorary Member. Any member or group of members may nominate individuals to the Board for Distinguished or Honorary Member. Sufficient documentary evidence on each nominee shall be furnished to the Board so that it may determine whether Constitutional requirements are met. The Board shall make a recommendation to Council within one (1) year of the date of each nomination. A majority vote of Council shall be required to elect a Distinguished or Honorary Member. Each President of the Society, immediately upon completion of his term of office, shall automatically become a Distinguished Member."

If you know anyone whom you believe should be a Distinguished or Honorary Member and your belief is strong enough for action, write a justification containing supporting factual data for the required qualifications and submit the draft of the justification to:

Frank W. Reinhart
National Bureau of Standards
Washington 25, D. C.

The author has been assigned the responsibility of the Past Presidents Advisory Board of preparing the final drafts for submission to that Board and finally to the Council.

—■—

Edited by **Thomas A. Bissell,**
SPE Executive Secretary

New from Emery Research

4 New Polymerics

Emery research has achieved a significant breakthrough in the field of polymeric plasticizers. Four new polymerics have been introduced to complement Plastolein 9720, the industry's largest selling polymeric. Together, they now give you a single source for a wide range of your plasticizer needs. Although Plastolein 9720 will continue to be the choice in uses demanding its ease of processing and low viscosity, the four new plasticizers meet other needs:

Plastolein 9722: An improved version of Plastolein 9720 in humidity and outdoor aging, compatability, extraction and migration—at the same low cost. (Formerly Emery 3282-D)

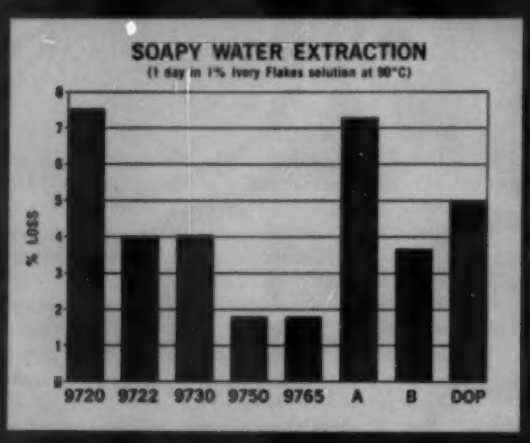
Plastolein 9730: Now, the lowest cost polymeric plasticizer featuring low migration properties, excellent outdoor stability, and good soapy water resistance. (Formerly Emery 3311-D)

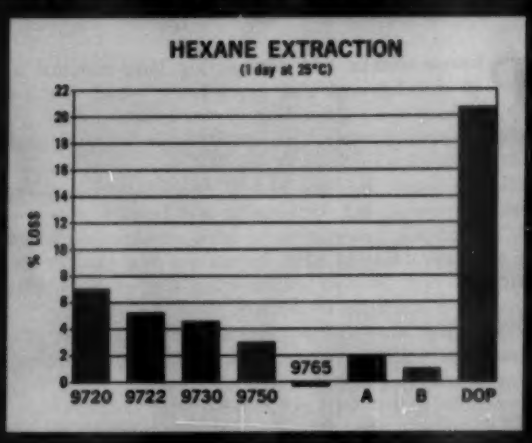
Plastolein 9750: A good, general-purpose, medium molecular weight polymeric at low cost, with excellent soapy water extraction and outdoor stability. (Formerly Emery 3313-D)

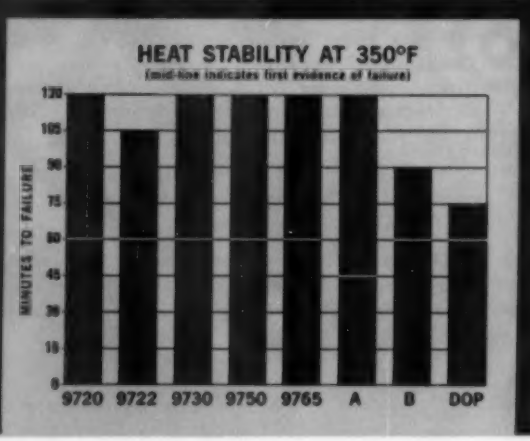
Plastolein 9765: The medium molecular weight polymeric plasticizer offering the best all-around permanence. Its cost is low, humidity aging outstanding, and extraction resistance tops. Special deodorized grade available. (Formerly Emery 3314-D)

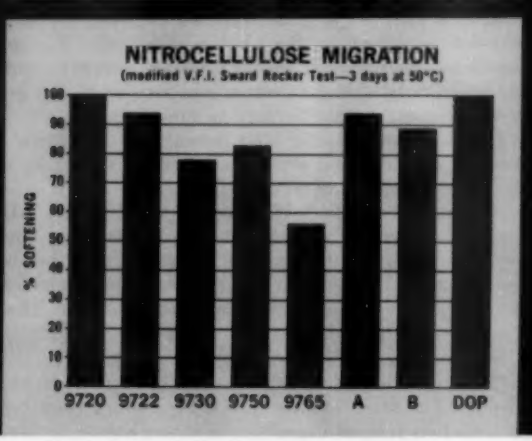
Extensive aging tests have been conducted by the South Florida Test Service. The Emery polymerics were compared with two leading competitive plasticizers and with DOP. Results show outstanding superiority of the Plastolein polymerics. Full information on the new Plastolein Polymeric Plasticizers including reproductions of test samples is available in Technical Bulletin 424. Write Dept. J-9.

Check Plastolein Polymeric performance on eight









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join famous Plastolein® 9720

POLYMERIC PLASTICIZERS FOR MANY USES

	PLASTOLEIN 9720	PLASTOLEIN 9722	PLASTOLEIN 9730	PLASTOLEIN 9750	PLASTOLEIN 9765
Coated upholstery fabrics	●	●	●	●	●
Unsupported films	●	●	●	●	●
Baby wear	●	●	●	●	●
Wall coverings	●	●	●	●	●
Vinyl-metal laminates	●	●	●	●	●
Industrial tapes		●	●	●	●
Shoe constructions	●	●	●	●	●
Surgical tapes				●	●
Plastisols, organosols	●	●	●	●	●
Coated paper	●	●	●	●	●
Pigment grinding	●	●		●	●
Refrigerator gaskets					●
Flooring	●	●	●	●	●
Hospital sheeting					●
Crash pads				●	●
Vinyl foam	●	●	●		

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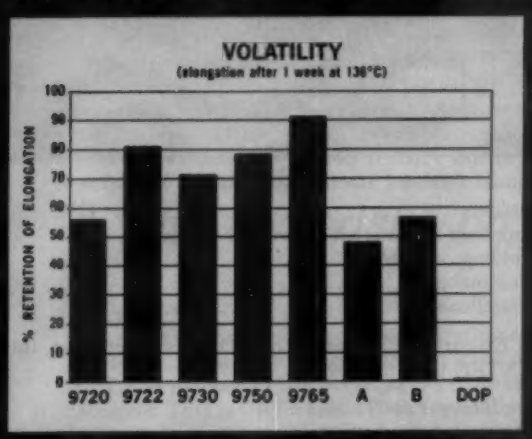
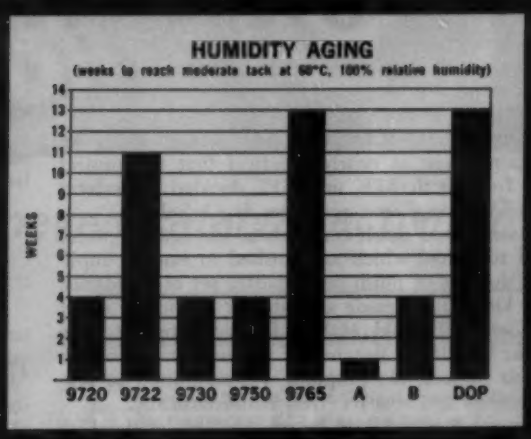
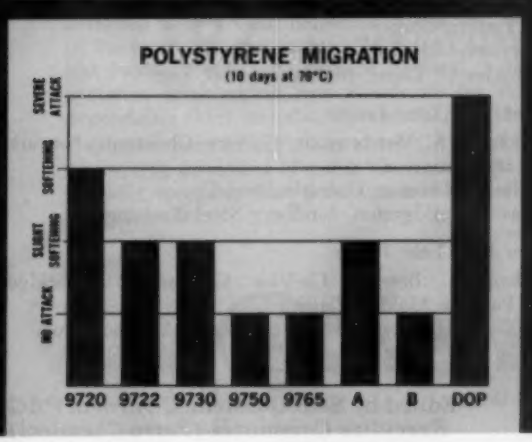
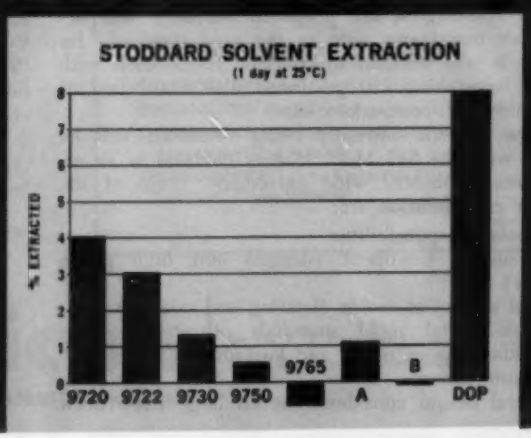








PAG Progress

Russell E. Schoeller, Chairman
Metal Mold Design and Construction PAG
(Sarcol Foundry & Pattern Corp.)

Mold Finish Standards Developed by Metal Mold PAG

Almost from the beginning of the plastics industry, molders, designers, toolmakers and other allied technicians have sought an adequate means for designating or specifying the degree of polish or finish required on a mold surface. Individuals and companies have established standards; none have received widespread recognition.

Over two years ago the Metal Mold Design and Construction Professional Activity Group was organized to evaluate the situation and to investigate the possibility of developing a standard which would be useful and acceptable to the molding industry as a whole. The group was formally organized under the leadership of Charles C. Davis, Jr., of Stokes Trenton Corp. At about the same time, the Mold Makers Division of The Society of the Plastics Industry was working along almost identical lines with William Monteith, Jr., of Akromold, Inc. in charge of the project. When the two groups became aware of the parallel nature of their work, it was agreed that each would carry on independently, but that they would try to coordinate their work as much as possible.

Although work continued in both groups the final results and conclusions were so nearly identical that the project committees from both SPE and SPI decided to submit identical proposals to their committees as a whole.

The proposed mold finish comparison kits are six pieces of hardened tool steel which are finished to exactly duplicate the six degrees of finish on a master set of standards. Comparison kits will be made available at a price of about $25.00 per set. SPI Mold Makers Division approved the sample set in late 1960. Because of the importance of the nature of this project, the proposal was submitted to several SPE Sections and was received enthusiastically.

At the Annual Business Meeting of the PAG at the 17th ANTEC in Washington the proposed standard was accepted by an unanimous vote as the new standards for mold finish. It was decided to continue cooperation with SPI and to have these kits produced and distributed as SPE-SPI mold finish comparison kits.

Many new projects currently being evaluated will be coordinated with the SPI Mold Makers Division in an attempt to create industry wide agreement. Some of the topics under consideration are;

1. moldmaker responsibilities
2. mold surface treatment (designs and high polish finishes)
3. thermal control of molds (heating and cooling)
4. available metal mold materials other than steel (beryllium-copper, nickel and kurksite)
5. mold automation
6. structural design considerations on large deep draw molds
7. tooling for expanded styrenes (mold design and materials)

The first topic is particularly important and the PAG is seriously considering the problem of trying to define and come to an agreement of moldmaker responsibilities because of the many daily misunderstandings in this area. Each molder and moldmaker seem to reach eventually some loosely defined area of agreement. In each case, however, this is almost completely verbal other than the few limitations on quotations or purchase orders, and these verbal agreements are often altered depending on the relative negotiation or bargaining ability of the individual concerned. Although the Group cannot hope to define completely the responsibility of the moldmaker, it hopes to be able to show certain areas of responsibility that are agreeable to all concerned. By stating them clearly, it may be possible to produce a basic definition which may be referred to by parties seeking a reasonable answer to disagreement occurring in the normal area of business operations.

The various segments of the plastics industry are represented in this PAG. A poll of the members present at the last Annual Business Meeting showed this breakdown:

Molders	42%
Suppliers of materials or services to the molding industry	27%
Moldmakers	23%
Miscellaneous	8%

The Executive Committee and Officers elected at the 17th ANTEC is as follows:

For Three Year Terms:

Russell E. Schoeller, Chairman, Sarcol Foundry & Pattern Corp.
Raymond H. Galpin, Romar Plastics Inc.
Charles C. Davis, Stokes Trenton, Inc.

For Two Year Terms:

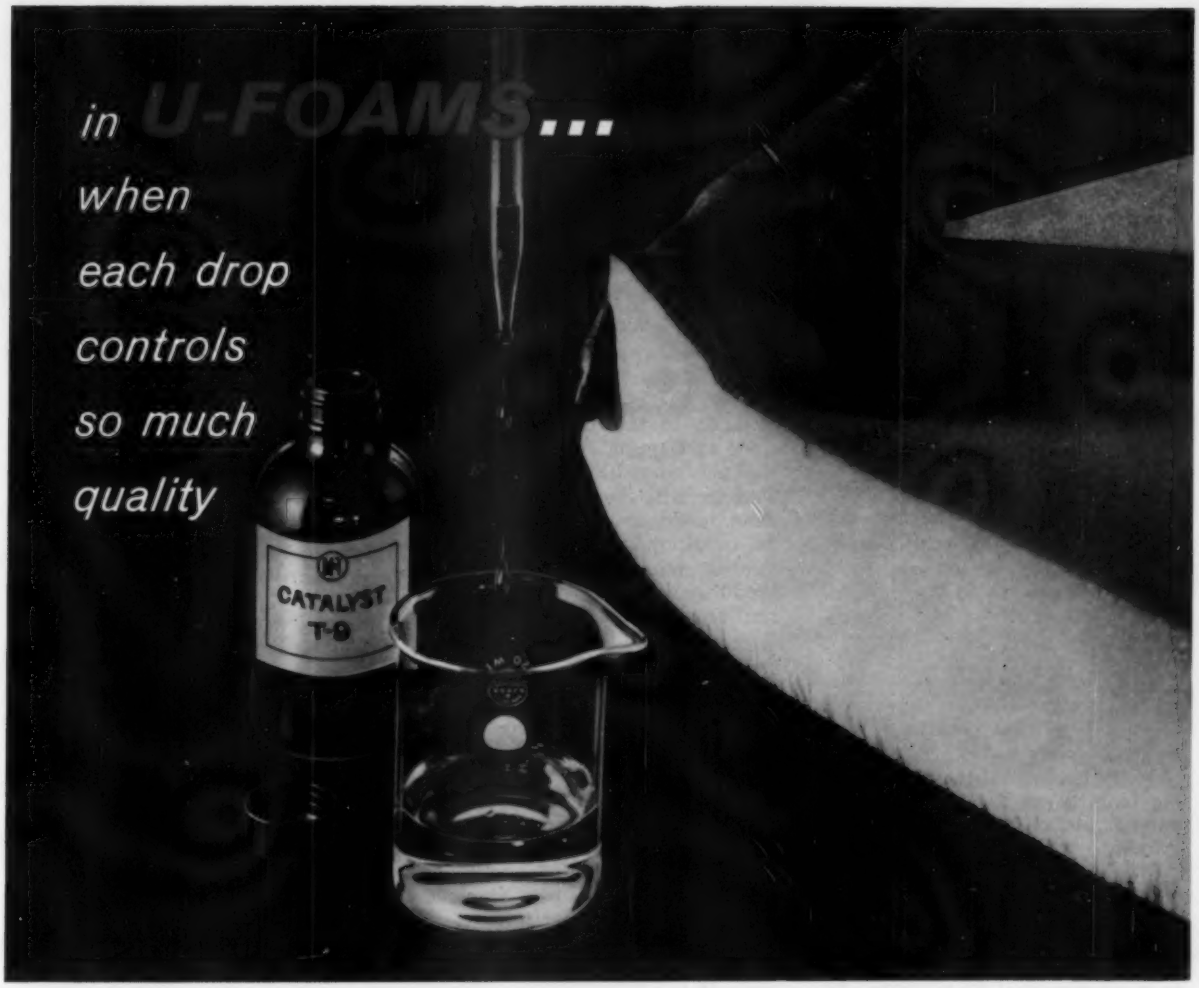
Nicholas S. Metrocavich, Co-Vice Chairman, Newark Die Co.
John G. Thomas, Crucible Steel Co.
David R. Edgerton, Lindberg Steel Treating Co.

For One Year Term:

Glenn S. Bowers, Co-Vice Chairman, Cambridge Panelite Molded Plastics Co.
William H. Monteith, Jr., Secretary, Akromold Inc.

—— ■ ——

Edited by **Saul Gobstein**, *Chairman PAG Executive Committee (Ferro Chemical)*



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PLASTICS AROUND THE WORLD

This month's column has been made possible through the contributions of these abstracters:
Hans Mayer (Industries des Plastiques Modernes)
Leonard Buchoff (Materials in Design Engineering)
Alfred Alk (Materie Plastiche and Poliplasti)

Italy

MATERIE PLASTICHE

MAY 1961

Plastics at the "Gold Compass" for 1960—pp. 423-435

The annual selection of manufactured articles which exhibit noteworthy design was held in Turin during February and March. The prize winning products are described and illustrated.

Plastics in Irrigation—pp. 485-498

Part 3 of this series is devoted to polyethylene pipe. Tables provide chemical and physical properties; uses illustrated. Methods of joining lengths are described, accompanied by sketches and photographs.

Hot Forming of High Impact Styrene Film and Sheets—pp. 436-448

The hot forming of sheets and film is a well known and highly diffused manufacturing method. Commercial procedures are described and illustrated with drawings and photographs. Molding techniques for continuous production of containers and door liners etc. are covered.

ABS—High Impact Polystyrene Mixtures with High Resiliency—pp. 449-462

High resiliency styrenes are mechanical mixtures of styrene polymers and co-polymers with various synthetic rubbers. The best known of these are SBR, styrene-butadiene, compounds which are called high impact grades. Superior impact properties are obtained with nitrile rubber and with nitrile copolymers. The term ABS as now used in commerce covers both mechanically mixed, two-component systems and three-component copolymeric materials.

Fabrication methods and techniques are described. A table lists physical properties of five common ABS polymers.

France

INDUSTRIE DES PLASTIQUES MODERNES

MAY 1961

Rubber and Plastic Combinations

The copolymerization of rubber—natural or synthetic—and plastics will permit a combination of the properties of both wherever compatability exists. Such combinations have been successfully produced with phenol-formaldehydes and polyvinylchlorides, the rubber content adding shock resistance to the phenol-formaldehyde and acting as a plasticizer to the polyvinylchloride. Impact resistance will also be added to styrene based resins, while in turn, an addition of polyethylene to rubber will result in a better modulus of elasticity producing a harder vulcanized end product.

Plastic Foils for Agricultural Applications and their Natural Ageing Process

Performance tests of polyvinylchloride foils in agricultural use, performed at the Saint-Auban testing plant, have been evaluated with the following conclusions:

A 50% plasticizer addition to the resin will give optimum results while getting best mechanical and ageing properties.

The ageing damage is reduced proportionally to additional thickness of the foil.

U.S.A.

MATERIALS IN DESIGN ENGINEERING

MARCH 1961

"What's new in Foam Plastics"—pp 119-134

The article takes up the following "news": Fluorocarbon-blown urethanes are replacing glass fiber in home refrigerators; Flexible urethanes are being used to produce foam in place for auto seating and furniture; Frothing or pre-expansion, produces more uniform large panels; Spraying foams has produced highly successful installations, but there are still many problems; Injection molding of expandable polystyrene beads and thermoforming of cellular polystyrene have opened new application areas; Fluorocarbon-blown epoxy foam is promising as refrigerator insulation.

"New Developments in Electrical Insulation Materials"—pp 107-110

Significant developments were reported at the recent National Conference on the application of Electrical Insulation. (1) Urethane foams are becoming increasingly popular for encapsulating electronic equipment. (2) Compreg, impregnated wood veneers, are used in switch gear because of their good electrical and mechanical properties. (3) Epoxy-glass tapes are available as Class H insulation. (4) Epoxy novalac cured with a mixture of nadic anhydride and hexahydrophthalic anhydride protects instruments in tough environments to 450°F. (5) Inorganic insulation permits transformer use at 1100°F. (6) Properties of electrical materials are related to molecular structure. (7) Using inert gases such as nitrogen and perfluoroethane protects insulation at high temperatures.

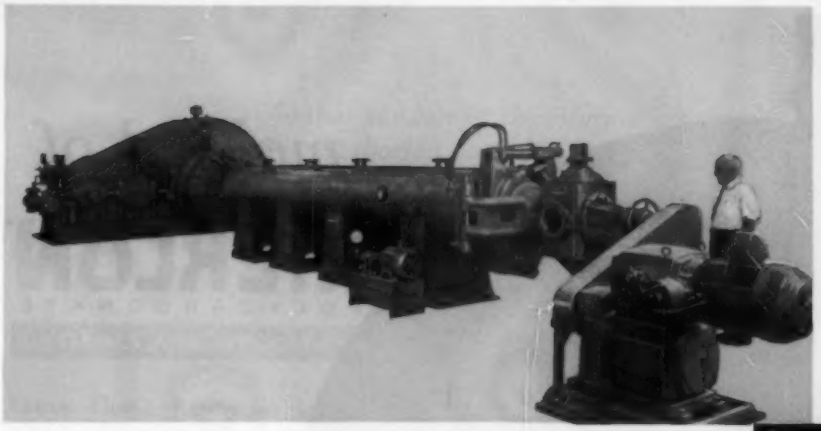
APRIL 1961

"What's New in Plastics"—pp 19-21, 147-156

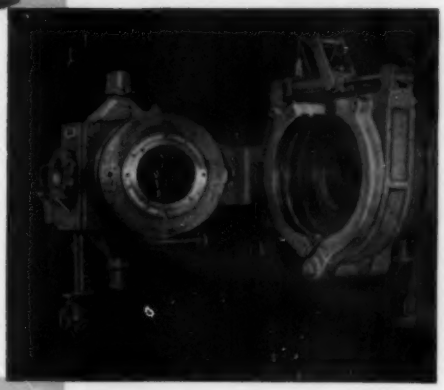
A new polyester film has superior water resistance, electrical properties and density. Oxirons show a lower rate of stress relation than conventional epoxies. Self-extinguishing liquid epoxy and polystyrenes are available. A new method for continuous filament-reinforced plastics is described.

"Environmental Tests for Elastomers"—pp 124-127

Standard test results are not always directly related to service experience. Parts in use are often shielded from degrading environments. Ozone attack on rubber is influenced greatly by stress. Laboratory chemical immersion tests cannot distinguish between fair and good materials. Interpretation of affects of temperature, aging, ozone and corona and fluid immersion are well presented with brief descriptions of ASTM tests.



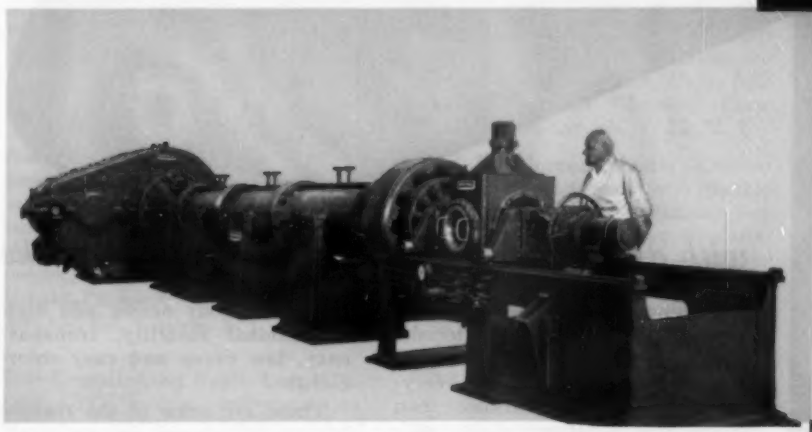
The machine at left is one of the largest underwater pelletizers ever built. Equipped with a 15" screw that is 30' long, it is driven by a 2000-hp motor and is designed for 10,000-psi working pressure. The head (shown open in the illustration below) is equipped with a hydraulic-clamp locking device.



Two examples of

underwater pelletizers

developed by Farrel for high-capacity extrusion



This cold-feed polyethylene extruder is driven by a 1500-hp motor and Dynamatic drive with a top speed of 100 rpm. Designed for head pressures of 10,000 psi, it is equipped with a long throttling ring. The head is mounted on rails so that after unlocking it can be quickly withdrawn.

FARREL®

Among Farrel's important contributions in the field of plastics processing has been the development of underwater pelletizers. While the two examples given are high-capacity machines, smaller extruders with underwater heads are also available.

These pelletizers are designed for the continuous working of plastics, operating as cold-feed machines or handling material direct from a Banbury® mixer or reactor. After working, the material is forced through a straining screen and then pelletized in an underwater head. Water is circulated through the head to separate the pellets and convey them to the cooling unit.

If you are interested, why not discuss this development with a Farrel engineer?

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.

Sales Offices: Ansonia, Buffalo, Akron, Chicago, Los Angeles, Houston, Atlanta

European Office: Piazza della Republica 32, Milano, Italy FB-1211

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with a diploma from the school of hard knocks

Designing protective headgear is a good way to learn about materials. Take a fireman's helmet, for example, that has to withstand everything a four-alarm disaster can throw at it. What would you make it of?

Starting over a year ago, Mine Safety Appliances Company, specialists in the design and manufacture of protective devices for industry, began the hard-headed investigation that led to the selection of Merlon polycarbonate as the material for their new line of fire and industrial safety headgear.

Reasons? Count 'em: 1) impact and puncture resistance greatly exceeding 40 foot pounds, 2) good dielectric properties, 3) high and low temperature resistance, 4) self-extinguishing qualities, 5) high flexural strength and rigidity, 6) high strength-to-weight ratio. For your needs, add high dimensional stability, transparency, low creep and easy colorability.

These are some of the reasons Merlon is the new quality standard of the high-impact engineering thermoplastics. For complete test data, comparative performance properties or technical assistance, write Mobay Chemical Company, Code 6118, Pittsburgh 5, Pa.

MOBAY

M-5

SPACE A-24 Plastics Show of Canada, Toronto, October 17-19

So that you can get the information you want in the shortest possible time, we suggest you write directly to the company address listed at the end of each new product item.

New Materials and Equipment

MATERIALS AND APPLICATIONS

Epoxy Flame Retardant Laminate A glass-base epoxy-resin laminated sheet is available. "Fireban 600" of NEMA equivalent FR-4 is self-extinguishing with high mechanical strength, excellent electrical properties and good chemical resistance. Bulletins available, *Dept. SPE,* **Taylor Fibre Co., Norristown, Pa.**

Artificial Dielectric Material Polyurethane foam produced with varying amounts of ferrous material results in plastic with a dielectric constant ranging from 1.2 to 3.0. High strength to weight ratio long-life are advantages to this material when used in microwave components. Information, *Dept. SPE,* **Polystructures Inc., 41, Montvalve Avenue, Stoneham, Massachusetts.**

Anti-Slip for Polyethylene, Polypropylene Films A new free flowing fatty amide "Kemstrene SU" was announced which is reported to offer slip and anti-block properties to these polyolefin films. Write *Dept. SPE,* **Humko Products, Chemical Div., 501 Allwood Rd., Clifton, N. J.**

Self-Crosslinking Resin Latex "X-Link 2833" a new vinyl-acrylic copolymer dispersion crosslinks without the addition of thermosetting resins to form strong flexible and impervious film. Stability, odor and compatibility problems are eliminated. Applications are in fabrics, wallpaper coverings, paper saturation, adhesives etc. Write *Dept. SPE,* **National Starch and Chemical Corp., 750 Third Ave., New York 17, N. Y.**

Hexachlorocyclopentadiene Typical reactions with hexachlorocyclopentadiene and pertinent structural formulas, physical data and handling procedures are presented in the manufacturer's bulletin. Among the end products are non-inflammable resins. Write *Dept. SPE,* **Hooker Chemical Corp., Niagara Falls, New York.**

Epoxy Curing Agent The commercial availability of liquid polyamide resins "Pentamid 1 and 2" has been reported. Resins produced by the condensation of polymerized fatty acids and polyamino compounds give blends with good flexibility, exceptional adhesion, high mechanical strength and superior chemical resistance. Inquire *Dept. SPE,* **Specialty Chemical Dept. Hayden Newport Chemical Corp., 342 Madison Ave., New York 17, N. Y.**

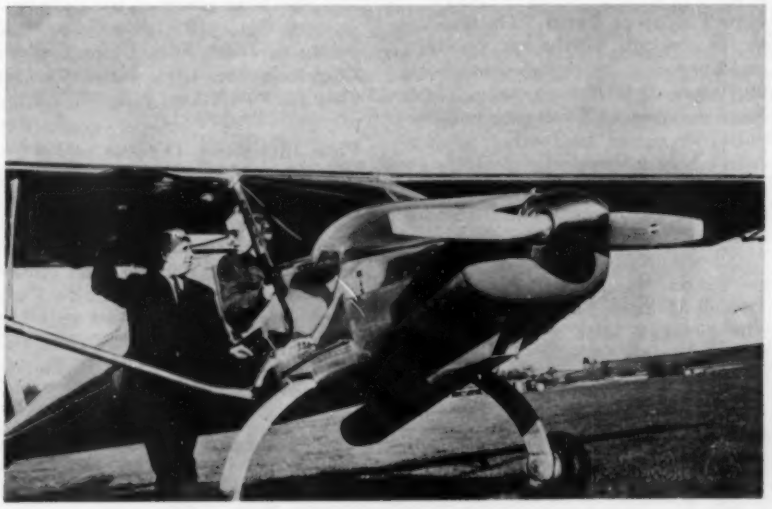
Low Cost Epoxy Curing Agent A low viscosity liquid at room temperature, readily miscible with liquid epoxy, is now available. Dodecenyl succinic anhydride, an aliphatic anhydride curing agent for epoxy resins, is said to offer formulators cost and weight reductions in finished parts, while still exhibiting toughness and flexibility characteristics. *Dept. SPE,* **Heyden Newport Chemical Corp., 342 Madison Ave., N. Y. 17, N. Y.**

New Reinforced Plastic Combining ablation resistance with thermal insulation and heat resistance, Tayloron 5000 is a new reinforced plastic, 25% lighter in weight than equivalent materials now available, according to the producers. Specific gravity of only 1.36 to 1.40 makes for considerable weight savings. *Dept. SPE,* **Taylor Fibre Co., Norristown, Pa.**

Improving Chrome Yellow Three new regent yellows which are chrome yellow pigments are said to be improvements developed for the plastics industry. In initial application, they are not as bright as conventional chrome yellows, but they darken much less on exposure. *Dept. SPE,* **Pigment, Color & Chemical Div., Sherwin-Williams Co., 260 Madison Ave., N. Y. 16, N. Y.**

Self-Adhering Polyethylene Film A 3-mil self adhering film has been formulated to provide excellent adhesion to uncoated board due to adhesion to the paper fibres. The need for special board is thus eliminated and material cost savings should be reduced. For information on film and processing. *Dept. SPE,* **Flexible Packaging Division of Continental Can Co., Mt. Vernon, Ohio.**

Fiberglas Under-Carriage for Planes The first Fiberglas-reinforced plastic under-carriage for airplanes has been produced by a Swedish company for use on an experimental light plane. The filament-wound part using Owens-Corning glass roving, has passed severe stress tests, particularly with respect to landing. *Dept. SPE,* **Owens-Corning Fiberglas Corp., 717 Fifth Ave., N. Y., N. Y.**



All-Plastic Windshield The advanced turbine-powered Boeing-Vertol 107 helicopters scheduled for commercial passenger and the military will use a new all-plastic aircraft windshield. Made of a very hard plastic, Sierracin 900, it can withstand abrasion such as that imposed by a windshield wiper. The material is used with high-strength acrylic plastic and vinyl. It is heated electrically by means of a special coating for hardness, also preventing icing and fogging. *Dept. SPE,* **Sierracin Corp., Burbank, Calif.**

Plastic Float "Barrel" A molded expanded polystyrene foam cylinder reinforced with galvanized mesh wire has been developed to replace metal barrels for floating barges, docks and boat houses. Reported absolutely unsinkable, rot and vermin-proof, it will support 480 pounds of dead-weight, and is said to have a longer functional life. *Dept. SPE,* **Cell-Foam, Inc., Ft. Worth, Texas**

New Polyester Resin Outstanding tensile strength, elongation, flexibility and toughness are reported attributes of Aropol Q-6030, a new polyester resin recommended for auto body repair compounds, and other applications where its particular qualities are desired. Suitable, too, for marine and outdoor applications, it can be readily blended with other resins developed by the company to improve their impact strength. *Dept. SPE,* **Archer-Daniels-Midland, 700 Investors Bldg., Minneapolis 2, Min.**

For Boats: Urethane Foam Systems Package systems for urethane foam flotation tailored to fit boat construction and working requirements will contribute to the safety of boating. The natural buoyancy of rigid urethane foam flotation is reported to have attracted the boating industry. *Dept. SPE,* **National Aniline Division, Allied Chemical Corp., Dept. NA 85, 40 Rector St., N. Y. 6, N. Y.**

Aleuritic Acid Commercially Available Until recently, Aleuritic Acid was obtainable only in experimental quantities and at a prohibitive cost as far as commercial applications was concerned. Now developed to the point where it is being offered at a price that will encourage its use in perfumery, pharmaceuticals, plasticizers, plastics, adhesives, etc. information can be obtained from *Dept. SPE,* **William Zinsser & Co., 516 W. 59 St., N.Y. 19, N.Y.**

Low Temperature Plasticizer For vinyl applications demanding good low-temperature performance, Flexol Z-88 has been introduced by Union Carbide Chemicals Co. Softly pliable, the new product will interest producers of coated fabrics and other vinyl products that must maintain their physical properties at both high and low temperatures. *Dept. SPE,* **Union Carbide Chemicals Co., Div., Union Carbide Corp., 270 Park Ave., N.Y. 17, N.Y.**

Pipe Jacketing Outdoor piping applications can be protected for as long as 20 years with a laminated facing material consisting of aluminum foil, glass reinforcing strands and duPont's new polyvinyl fluoride film called "Tedlar." American Sisalkraft's Pyro-Kure bonds these sheets together. *Dept. SPE,* **American Sisalkraft Co., Div., St. Regis Paper Co., 55 Starkey Ave., Attleboro, Mass.**

Low Inhibitor Level Monomers Methyl acrylate and ethyl acrylate monomers are now available which have an inhibitor concentration of only 15 parts per million, according to Rohm & Haas. These monomers are said to be safe to handle and ship, maintaining their stability under extreme storage conditions. *Dept. SPE,* **Rohm & Haas Co., Special Products Dept., Washington Square, Philadelphia 5, Pa.**

Plastics in Camping! Trailers, molded from glass fibers and Vibrin polyester resin produced by the Naugatuck Chemical division, U.S. Rubber Co., have been placed on the market in California. One tiny trailer, just over ten feet long, comes with a reinforced plastic boat, mounted, bottom up, on its roof. Sleeping area for two, cooking and storage facilities, the light weight, nonrusting, impact-resistant, reinforced plastic trailer provides shelter for the camper without a tent. *Dept. SPE,* **United States Rubber Co. 1230 Ave. of the Americas, New York 20, N.Y.**

EQUIPMENT

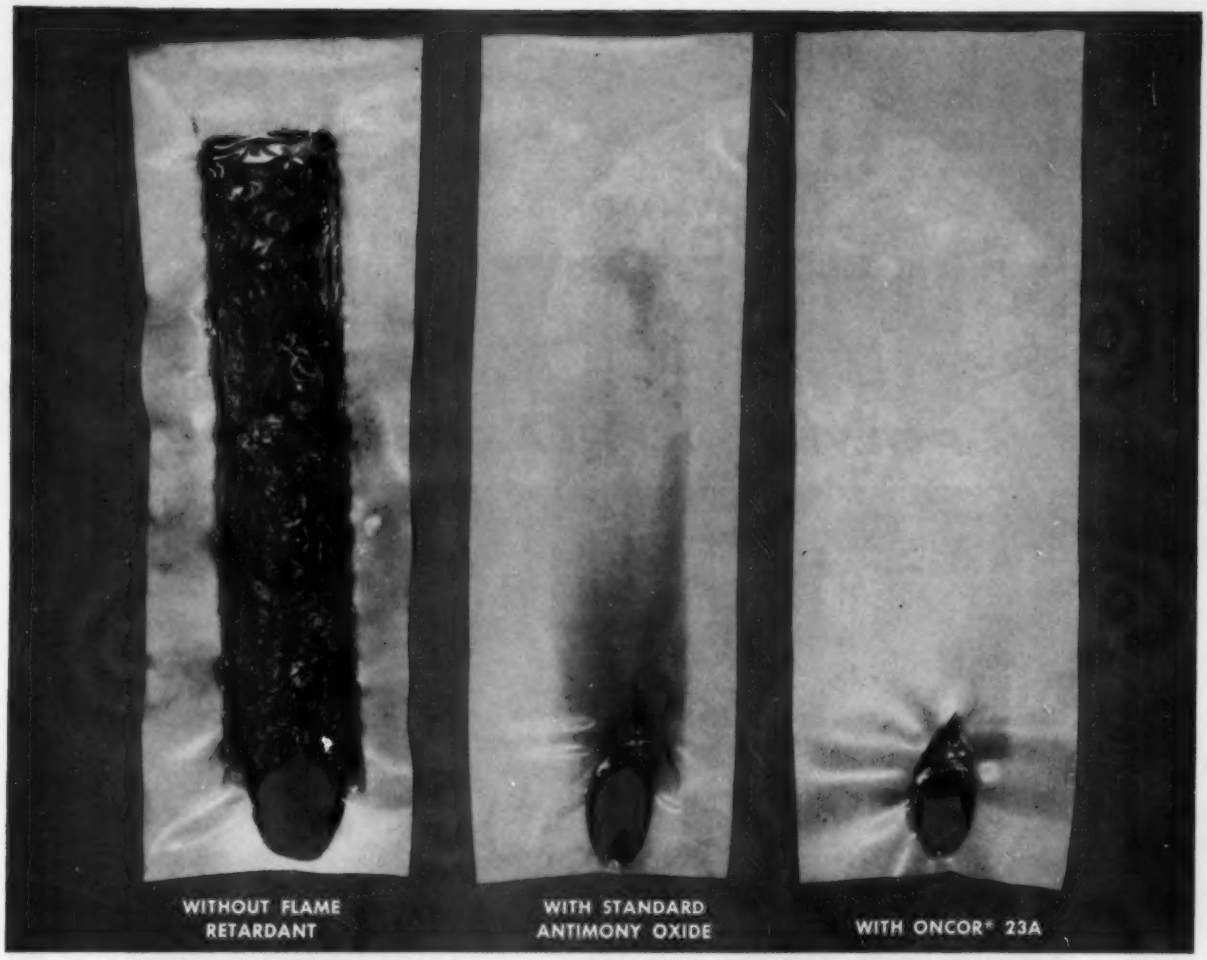
New Automatic Heat Sealer The Blistpack heat seals through the card and plastic material permitting perfectly sealed blister packages without deformation, product damage and heavy card warpage. The operation is said to be both simple and safe. *Dept. SPE,* **Tronomatic Corp., 25 Bruckner Blvd., Bronx 54, N. Y.**

Automatic Screen Changer With no moving parts to cause leakage problems, an automatic screen changer (patent applied for) is said to have increased reliability, in comparison to the units having a sliding breaker plate. *Dept. SPE,* **Sterling Extruder Corp., 1537 W. Elizabeth Ave., Linden, N. J.**

New Heat Sealer Perfectly sealed blister packages, said to keep card warpage or product damage to a minimum, are possible with a new automatic heat sealer, according to Tronomatic Corp. of N.Y., the manufacturer. The BlisTpack joins card and blister at their contact point at a minimum heat. *Dept. SPE,* **Tronomatic Machine Mfg. Corp., 25 Bruckner Blvd., Bronx 54, N.Y.**

Electron Accelerators for Plastics Irradiation A new low-energy electron accelerator, Model ICT, features a 300-600 KV power supply and sep-

(continued on page 1019)



Typical results of recent flammability tests on 6 mil PVC film, following ASTM Method D 1433-56T. Antimony oxide and ONCOR 23A used at 5% level (resin basis)

Tests show effectiveness of

Oncor* 23A pigment...the cost-saving flame retardant for chlorinated-resin compounds

Effective, uniform flame retardance—the basic function of ONCOR* 23A—is combined with three important processing advantages that can add up to substantial economies in electrical insulation, paints, vinyl films or dipping plastisols.

Specific gravity is lower than that of conventional antimony oxides. ONCOR 23A has a *surface layer* of antimony oxide fused to an inert, lightweight silica core. The result is greater efficiency for every pound of antimony—at lower cost per pound. 23A is the most economical way to use an antimony oxide flameproofing agent.

Tinting strength is low and uniform—consistently 50% of a standard antimony oxide. Colorants can be used more effectively . . . smaller quantities are needed.

Dispersion is easy and uniform in plastics and paints. ONCOR 23A pigment particles are unusually uniform—the result of careful production controls.

Make your own evaluation tests. Find out the product and process advantages of ONCOR 23A pigment—in any halogenated plastic composition that needs flame resistance. It can be used with polyvinyl chloride, vinyl chloride copolymers, chlorinated paraffins, chlorinated rubber, chlorosulfonated polyethylene, chlorinated polyesters and commercial fluoropolymers.

*Trademark

MAIL COUPON FOR ADDITIONAL INFORMATION

NLC

NATIONAL LEAD COMPANY KC-9900-D
General Offices, 111 Broadway, New York 6, N.Y.
In Canada: 1401 McGill College Ave., Montreal, Que.

Gentlemen: Please send latest data on ONCOR* 23A antimony silico oxide pigment for flame retardance in halogenated plastics and paints.

Name_____ Title_____

Company_____

Address_____

City & Zone_____ State_____

23A *an* **oncor** *Pigment...A Development of* **National Lead Company**

General Offices: 111 Broadway, New York 6, N. Y.

NEW IMPROVED

HARFLEX® 330

POLYMERIC PLASTICIZER

NEW FREEDOM FROM TASTE AND ODOR TRANSFER

Harflex 330 is a non-migratory plasticizer of excellent permanence. It assures freedom from high taste and odor transfer to food from refrigerator gaskets.

In addition, Harflex 330 has good resistance to migration into polystyrene, lacquer and varnish as well as extraction by water, soapy water, oil and gasoline. Its stability under humid conditions is excellent. Tests prove its electrical measurements outstanding and its dielectric strength, both dry and after immersion in water, very high.

You'll find Harflex 330 an all-round efficient plasticizer offering true economy.

Write for Bulletin or Consult Chemical Materials Catalog, Pages 159-161.

WALLACE & TIERNAN INC.

HARCHEM
THE KEY TO BETTER PLASTICS

HARCHEM DIVISION | **25 Main Street**
Belleville 9, New Jersey

IN CANADA: HARCHEM LIMITED, TORONTO

(continued from page 1016)

arate electron acceleration tubes for process line polymerization and sterilization of plastic materials. Write, *Dept. SPE,* **High Voltage Engineering Corp., Burlington, Mass.**

Laboratory Scale Film Stretcher Fifty, four-inch square samples can be stretched uni and bi-axially by an automated operation. The effects of all combinations of the physical properties can be determined in the laboratory and plant machinery loads predicted. *Dept. SPE,* **T. M. Long Co., Somerville, New Jersey.**

New Lifting Magnets Two lightweight industrial magnets with lifting capacities of 1500 and 4500 pounds have been developed for use in mold and die plants and other metal-working operations. Time savers, the My-T-Mags end damage to finish ground surfaces. A built-in rectifier enables operation on any 110/120 volt line, either AC or DC. *Dept. SPE,* **D-M-E Corp., 6686 E. McNichols Rd., Detroit, Mich.**

New Vacuum Oven Designed to permit rapid removal of moisture from thermoplastics down to laboratory standards in production quantities, a new vacuum oven has been developed that is said to be reasonably priced. Available for immediate delivery from stock for 220 volt operation, the new oven is reputedly free of troublesome desiccants and costly dehumidifiers. Write, *Dept. SPE,* **Injection Molders Supply Co., Inc., 17601 South Miles Road, Cleveland 28, Ohio.**

Blown Tubing Dies New blown tubing dies (patent applied for) have been designed with rotation permitting any non-uniformity of gauge or high spot to be traversed over the entire width of the reel, providing a fully wound roll with a completely flat surface. Side opening on the die permits extrusion of heavier gauge film as well as higher blow-up ratios. *Dept. SPE,* **Sterling Extruder Corp., 1537 W. Elizabeth Ave., Linden, N. J.**

LOOKING FOR A CATALYST FOR THE POLYMERIZATION OF VINYL CHLORIDE?

TRY **ALPEROX C**®

SPECIFICATIONS.

Lauroyl Peroxide	95.0% (Min.)
Active Oxygen	3.76% (Min.)
Free Fatty Acids as Lauric Acid	1.5% (Max.)
Alkaline Soaps as Calcium Laurate	1.5% (Max.)

THERMAL DECOMPOSITION.

Material	Solvent	Temp. °C.	Half Life in Hours
ALPEROX C	Benzene	100	0.1
Benzoyl Peroxide	Benzene	100	0.33
ALPEROX C	Benzene	70	3
Benzoyl Peroxide	Benzene	70	12

ALPEROX C (Technical Lauroyl Peroxide) is the preferred catalyst for the suspension polymerization of vinyl chloride. Concentrations of 0.1 to 1.0% confer greater heat stability on the final product and facilitate higher conversion velocity. As a catalyst for curing polyester resins, it is especially applicable to the production of small, clear, transparent castings, setting at a temperature of 60° to 80°C. For cold setting with tertiary amines as accelerators, less discoloration occurs than when using benzoyl peroxide.

WRITE FOR DATA SHEET

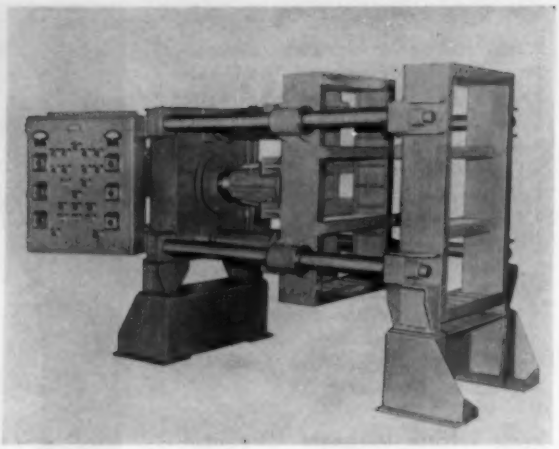
LUCIDOL DIVISION

WALLACE & TIERNAN INCORPORATED
1740 MILITARY ROAD
BUFFALO 5, NEW YORK

KILL STATIC WITH A GUN!

Simco Ionizing Air Guns will put an end to static woes in any finishing operation! Plastic parts are blown clean, while being neutralized, so that dust, dirt and lint are *completely* removed and will not be reattracted! This new electronic air gun is safe, easy to use, and *guaranteed* effective! Write for facts.

the SIMCO company
920 Walnut Street, Lansdale, Pa.



Polystyrene Molding Machine Any mold or group of molds up to 30" x 50" area, clamped under force of 50 pounds per square inch can be handled by a new expandable polystyrene molding machine. The stroke of the press can be modified with standard strokes obtainable, 16", 24", 30", and 44". A patented air hydraulic cylinder keeps the oil heat down and special features of the resin reduces maintenance costs due to leakage. *Dept. SPE,* **Tronomatic Corp., 25 Bruckner Blvd., Bronx 54, N. Y.**

MANUFACTURERS' LITERATURE

Polycarbonate Films A new General Electric Bulletin, CDC-396, presents preliminary data on the physical and electrical properties of the company's LEXAN, digesting present and potential uses. *Dept. SPE,* **General Electric Co., Pittsfield, Mass.**

Specialty Plasticizers Data Sheet A new booklet, issued by Chas. Pfizer & Co. takes up Morflex Specialty Plasticizers. The data sheet, No. 560, is the work of the Chemical Sales Division and reviews pertinent specifications, properties and performance. *Dept. SPE,* **Chas. Pfizer & Co., Inc., 235 E. 42 St., N.Y. 17, N.Y.**

Concerning Aldehydes The uses and properties of aldehydes are contained in a new 45-page booklet published noting constant-boiling mixtures, specification limits, test methods, storage, handling, etc. *Dept. SPE,* **Union Carbide Chemicals Div., Union Carbide Corp., 270 Park Ave., New York 17, N.Y.**

Epoxy High-Temperature Properties A six-page bulletin describing high temperature properties of Oxiron epoxy resins used in wet layup, prepreg and printed circuit applications, along with data on custom tailored curing systems is available. Write for Bulletin No. 2, *Dept. SPE,* **Epoxy Dept., Food Machinery and Chemical Corp., 161 E. 42 St., N. Y. 17, N. Y.**

Processing Cast Polypropylene Films Hercules Powder Co. offers a new technical booklet providing information on the processing of cast polypropylene films. The 12-page booklet is divided into sections covering market, properties processing, converting and packaging. Hercules "Profax" has been approved by FDA for use in products coming into direct contact with all kinds of food. *Dept. SPE,* **Hercules Powder Co., 910 Market St., Wilmington 99, Del.**

White Oil on Plastics A nine-page research bulletin is being offered where current and proposed applications are discussed. Functions such as compressor lubricants, catalyst carriers, plasticizers, dust reducing agents, internal lubricants, mold releases and annealing agents are reviewed. Write *Dept. SPE,* **Sonneborn Chemical and Refining Corp., 300 Park Ave. S., N. Y. 10, N. Y.**

About Alcohols Comprehensive data on 21 alcohols from methanol to tridecanol is included in a new 80-page booklet published by Union Carbide Chemicals Co. Described are those used in many industrial and consumer products, with sections also set aside for reports on physical properties, constant-boiling mixtures, test methods, specification limits, etc. *Dept. SPE,* **Union Carbide Chemicals Co., 270 Park Ave., N. Y. 17, N. Y.**

Machining Laminated Plastics A brochure describing techniques and that provides general machine information is available. Recommendations of tools speeds, feeds, cooling and lubrication are given for each operation. Write *Dept. SPE,* **Synthane Corp., Oaks, Pa.**

Commercial Standards for Plastic Pipe Recognized specifications for plastic sewer pipe of 8" diameter or larger are presented in Commercial Standard 228-61 which supersedes 228-60. It will be available from the Superintendent of Documents. For the earlier copy, *Dept. SPE,* **Evanite Plastic Co., Carrollton, Ohio.**

Amino-Containing Methacrylates Commercial quantities of dimethylaminoethyl methacrylate (DMAEMA) and tert. -butylaminoethyl methacrylate (t-BAEMA) are obtainable. They provide means of introducing pendant reactive amines into plastics and can be used as intermediates because of the reactivity of the amino groups and double bond. Water soluble and acid soluble polymers may be produced along with thermosetting acrylic coatings as examples of the many applications listed. For booklet, *Dept. SPE,* **Rohm & Haas Co., Washington Square, Philadelphia 5, Pa.**

Plastic Tool System Two bulletins are available as a guide for creating laminated tools for use at 350°F with epoxy resins. Properties, cure cycle, packaging and handling are discussed. Write *Dept. SPE,* **Smooth-On Mfg. Co., 570 Comminipaw Ave., N. J.**

Diverse Fibre Glass Applications A new eight-page brochure entitled, "Focus on Fibre-glass" is intended as a process selection guide for designers and production specialists. Filament winding and centrifugal molding are discussed in addition to manufacturing methods, and quality control techniques are appraised. Write *Dept. SPE,* **Apex Reinforced Fibre-Glass Division, Washington and Elm Streets, Cleveland 13, Ohio.**

Plastic Gate Cutters Sixteen-page buyers guide to plastic gate cutters has been published by Injection Molders Supply Co. Illustrations, specifications and prices are given on thirteen models. *Dept. SPE,* **Injection Molders Supply Co., Inc. 17601 South Miles Road, Cleveland 28, Ohio.**

Adhesives for Structures

Symposium on Adhesives for Structural Applications

Chairman, W. J. Powers, *Deputy Chief for Research,* Plastics and Packaging Laboratory, Picatinny Arsenal.

Welcome, Col. R. R. Klanderman, *Commanding Officer,* Picatinny Arsenal.

Introductory Remarks, Mr. Paul S. Forsyth, *Office Director* Def. Res. & Eng.

Ordnance Materials Research Program, Dr. J. L. Martin, *Director,* Ordnance Materials Research Office.

First Session—Design of Joints and Adherend Surface Preparation

Session Leader, Mr. M. J. Bodnar, *Chief,* Materials Research Section, Picatinny Arsenal

Design of Joints	Mr. L. R. Lunsford, Convair, Ft. Worth
Joint Design for Primary Structures	Dr. Norman A. de Bruyne, CIBA (A.R.L.) Limited England
Metal Adhesive Peel Testing	Dr. Steven Yurenka, Narmco Industries, Inc.
Methods for Determining Stress Distribution in Adherends and Adhesives	Mr. D. F. Fouser, Douglas Aircraft Company, Inc.

Second Session—Selection of Adhesives and Process Control

Session Leader, To be named

Adherend Surface Preparation	Mr. Edmund Thelen, Franklin Institute Laboratories
Structural Adhesives Characteristics and Application	Mr. Nicholas J. DeLollis, Sandia Corporation
Importance of Evaluation of Adhesives for All Environmental Conditions and Permanence Studies	Dr. Richard F. Blomquist, Forest Products Laboratory
Significance of Good Process Control	Mr. F. H. Bair, Aeronautical Systems Divisions, USAF
Process Control in Production Applications	Mr. William Bandaruk, Aeronutronic Systems, Inc.

"Modern Structural Adhesives Technology" will be the subject of a symposium to be held on September 27-28 at Picatinny Arsenal, Dover, New Jersey. The symposium is being organized by Mr. M. J. Bodnar, Chief of Picatinny's Materials Research Section and head of the adhesives research group. Chairman will be Mr. W. J. Powers, Deputy Chief for Research in the Arsenal's Plastics and Packaging Laboratory, which has the U.S. Army Ordnance mission responsibility on adhesives.

Third Session—Special Applications for Adhesives

Session Leader, Mr. Harry E. Pebly, Jr., *Director, PLASTEC,* Picatinny Arsenal

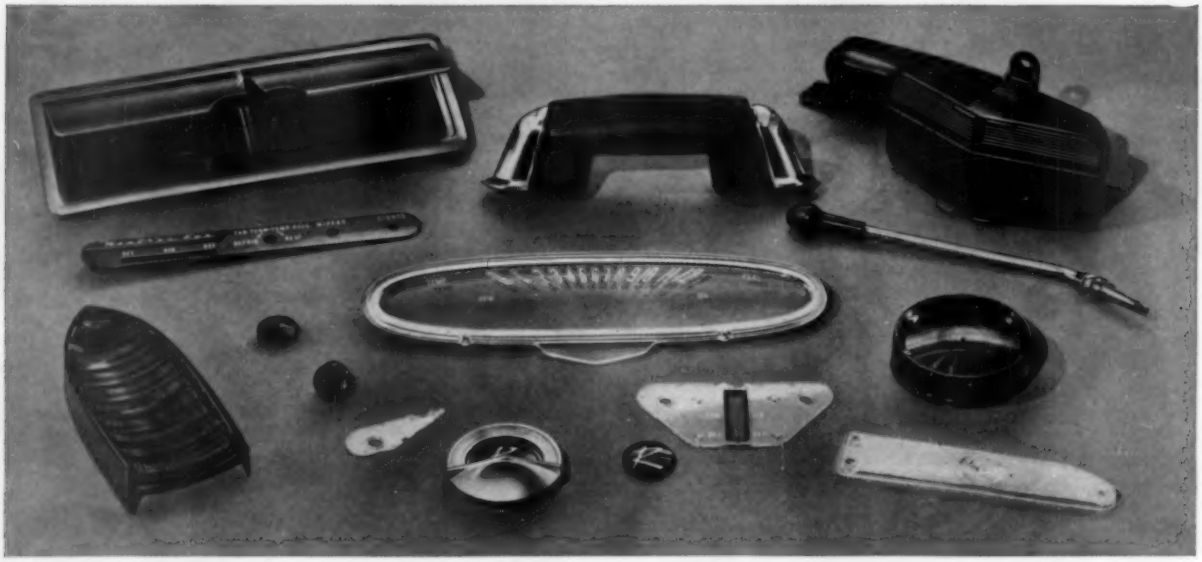
Adhesives in Printed Circuit Applications	Mr. D. K. Rider, Bell Telephone Laboratories
Special Adhesives for Rubber Bonding	Mr. Charles H. Peterson, Lord Mfg. Company
Treating Teflon and Kel-F to Improve Adhesive Bonding Characteristics	Mr. A. A. Benderly, Diamond Ordnance Fuze Laboratories
Adhesive Bonding of Reinforced Plastics	Mr. H. A. Perry, Naval Ordnance Laboratory

Fourth Session—Recent Developments in Adhesives

Session Leader, Mr. Marco Petronio, Frankford Arsenal

Recent Developments in High Temperature Adhesives	Mr. Harold H. Levine, Narmco Industries, Inc.
High Temperature Ceramic Adhesives	Mr. John B. Whitney, The Boeing Airplane Company
Room Temperature Curing Adhesives for Structures	Dr. Jack Dickstein, The Borden Chemical Company
Potential of Adhesives for the Future	Mr. George Epstein, Aeronutronic Systems, Inc.
Adhesives in Ordnance Applications	Mr. W. C. Tanner, Picatinny Arsenal
Adhesives in Production Applications (Slides)	Mr. L. R. Lunsford, Convair, Ft. Worth
Summation and General Discussion	Mr. W. J. Powers, Moderator

Handsome and Hardworking
Plexiglas...Implex



Why are there so many parts molded of IMPLEX®, the high-impact acrylic, and PLEXIGLAS® acrylic plastic on the 1961 Ramblers? Here are the reasons.

IMPLEX is used for metallized armrest supports because of its superior *toughness* . . . for air conditioner housings and grilles because of its excellent *appearance*, its *strength* and good *moldability* in thin sections . . . for radio, window crank and gear shift knobs because of its *dimensional stability* and *stain resistance*.

PLEXIGLAS is used for tail light, back-up and parking light lenses because of its outstanding *optical properties* and *weather resistance* . . . for the speedometer dial because it calls for *edge-lighting* . . . for medallions and other ornaments because the *crystal clarity* of PLEXIGLAS gives depth and sparkle to the back-surface decorations.

These Rohm & Haas molding materials may well benefit a part on which you are working. Our design staff will be pleased to help you use them to your advantage.

ROHM & HAAS

PHILADELPHIA 5, PA.

In Canada: *Rohm & Haas Co. of Canada, Ltd., West Hill, Ontario*
Detroit Representative: *R. C. Oglesby, Nor-Way Building, 20211 Greenfield Road, BRoadway 3-0674.*

EIGHT INSTITUTIONS REPORT PLASTICS IN BUILDING ACTIVITY AT BRI SPRING CONFERENCE

The SPE was one of eight organizations active in the Plastics in Buildings field that reported progress at the 1961 Spring Conference of the Building Research Institute, Washington, D. C., May 16-19. Excerpts follow:

SOCIETY OF PLASTICS ENGINEERS—Armand Winfield, Chairman of the SPE Plastics in Buildings Professional Activity Group (PAG) and its Traveling Educational Exhibit, summarized the activities of the SPE, his PAG and its Exhibit.

"Standardization of plastic materials and dissemination of technical data on a ground common to all parties concerned —the architect, builder, contractor, and plastics technologist—so each may understand the others' terminology in a familiar frame of reference," he pointed out, "are needed urgently if plastics is to realize its potential in building applications. Activities of SPE PIBPAG, including its Exhibit and catalog," he explained, "are aimed at filling these urgent needs."

BUILDING RESEARCH INSTITUTE reported activities of its Planning Committee on Plastics in Buildings. The Committee's objectives are four:

1. To inform the building industry of development in plastic materials as they apply to building products.
2. Assist the building industry in the selection, design and application of plastic materials and products.
3. Secure for the plastics industry a better concept of building functions, operations and requirements to guide product and application developments in plastic materials.
4. Keep the building industry appraised of the progress and performance of plastic products.

The Committee consists of six plastic materials manufacturers; five building material manufacturers, two architects, three building owners and operators, one builder, and two educators.

Since 1955 the Committee has sponsored annual or semi-annual BRI Conferences covering application of plastics to: the building skin, weather-resistant building construction, interior surfaces, roof construction, building illumination, control of building environment, sandwich panels, and preassembled components. New development, architectural requirements, code approvals, and the 1961 activity reports are other topics of committee conferences.

A basic product information format to assist architects and builders to appraise and select building products has been developed and will be promulgated throughout the plastics and building industry for acceptance as a uniform method of presenting data.

SOCIETY OF THE PLASTICS INDUSTRY presented four reports covering its Fiberglass Reinforced Panel Council, Thermoplastic Pipe Division, Building Code Advisory Committee, and Flammability Committee-Cellular Plastics Division.

The Fiberglass Reinforced Panel Council consists of representatives of panel producers and raw material suppliers. Its purpose is to develop test procedures for measurement of properties of reinforced plastic panels, including diffused light transmission, transverse strength of corrugated panels, bearing load, dimensional requirements, intrinsic quality, safe use practices, and cooperation with municipalities.

". . . In 1960 three hundred million feet of plastic pipe were produced by the extrusion process in the United States by by some forty different manufacturers, located in every section of the country, and operating from such diverse facilities as one man converted garages, the more typical new modern plants constructed especially for this purpose, and by new divisions of multi-million dollar long-established corporations.

"Thermoplastic materials used in the production of this pipe included: polyethylene, acrylonitrile-butadiene-styrene multi-polymers (ABS), polyvinyl chloride (PVC), cellulose acetate butyrate (CAB), and high impact styrene blends. Other thermoplastic materials, such as penton, polypropylene, and acetyle resins, were less extensively used. Many of the applications were such that pipe made from any of these resins could have been used interchangeably. Many, on the other hand, were such that pipe made from one type of resin performed its function better than pipe made from any other resin. Seeing to it that the right type of resin was used for the right type of pipe made to the right set of dimensions was one of the major problems of both consumer and pipe manufacturer. The consumer was concerned with the immediate demand on his pocketbook—the manufacturer with the future of an industry.

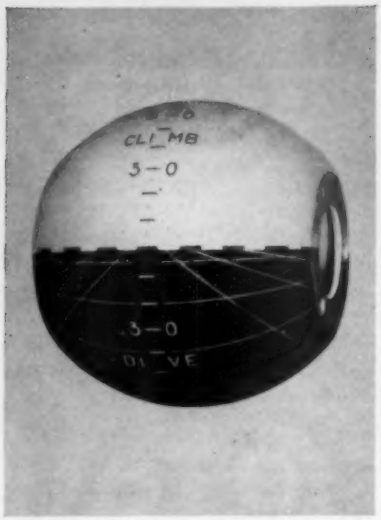
"The helping hand in this mutual struggle for maturity has certainly been that of the consumer and his agencies. The guiding hand has been that of the pipe manufacturer himself, performing his function in the battle of supply and demand while engaged in his fight for survival in a fiercely competitive market. When this competitive spirit itself seemed to thwart his very goals, the pipe manufacturer created an organization to perform his collective bidding, and, being a part of his creation, entrusted it to do for him that which he could not do alone. He called it the Thermoplastic Pipe Division of the Plastics Industry."

". . . The SPI Building Code Advisory Committee was organized six years ago at a time when several distinctly different segments of the industry found that, as they reached larger and larger markets in the building construction field, they were beginning to run up against code barriers. As long as plastics in building construction was an experimental or developmental matter, as long as the total amount of plastics volume going into the building field was insignificant, and as long as plastic products for building use had no particular trade name or product identity, their occasional appearance on building plans raised few serious questions. However, when building officials began to find that plastic installations were frequently becoming an important architectural or functional part of the design of buildings, and when the use of plastic glazing or skylighting was becoming common in metal buildings, they began to ask under what provisions of the building codes the new materials were being offered. Then, understandably, the wide range

G-E LEXAN® POLYCARB

STABLE ELECTRICALS. Binding posts made of LEXAN resin retain electricals even under moist, hot conditions. They do not loosen, are molded in six attractive LEXAN colors for coding. Other features are: low loss and power factor, low dielectric constant, high voltage insulation, non-sink surfaces.
(Superior Electric)

HEAT RESISTANCE. Beautiful handles of LEXAN polycarbonate resin are used in rugged service on U.L. approved soldering irons. They resist the impact, heat and abrasion of daily bench work. The hard, glossy handles are light in weight. Molded in three pastel colors, they provide toughness and sales appeal.
(Ungar Electric Tools)



DIMENSIONAL STABILITY. Maximum allowable change in this 5-inch aircraft instrument part is only 5 mils over a temperature range of —65° to 300°F! And it must maintain this tolerance under high humidity. Part is injection molded of LEXAN resin as half spheres which are solvent cemented, lathe-turned and painted. (Lear, Inc.)

of plastics presented a confused picture and the average building inspector or department head found himself unable or unwilling to judge the merits of any particular product. There were no coordinate reference data which might guide the industry and the building official in the problem of what plastics and how much should go into various types of buildings in this location or that location, and so the industry found itself frequently faced with the easiest solution to the building department's problem, namely refusal to approve or allow the installation."

"In 1955, the Society of the Plastics Industry found that the number and nature of the problems which the industry faced before building departments around the country, and the number of products and companies involved, were so large as to require a special discussion session and organizational meeting to take concrete constructive steps to overcome any immediate problems, and develop a program aimed at obtaining fair building code legislation for plastic materials. As a result of its deliberations at this meeting, the present Code Advisory Committee was organized."

". . . The Flammability Committee was formed in November, 1958. . . . Initial work was centered around discussions of specific problems regarding flammability that the Division Members had encountered. . . .

"In July, 1959, a task force studied the test method in Underwriter's Laboratories Bulletin 484 on Air Conditioners. . . .

"Also in July, 1959, the Test Methods Sub-Committee was formed. . . . The work of the Flammability Committee has since been centered entirely in this sub-committee. Two task forces in turn were organized. . . .

"The Long Range Task Force catalogued all of the known test procedures used for foams into two categories:

1. Burning Characteristics of Cellular Plastic Materials
2. Burning Characteristics of End Use Products Containing Cellular Plastics Materials. . . .

"In November 1960, the Long Range Task Force organized a series of Round Robin Tests on Plastics Foams. The purpose of this series is three-fold:

1. To determine the difference in results obtained on the same materials with different tests.
2. To determine the difference in results obtained on different samples with the same tests.
3. Carry out some experiments on modifications of standard tests. . . .

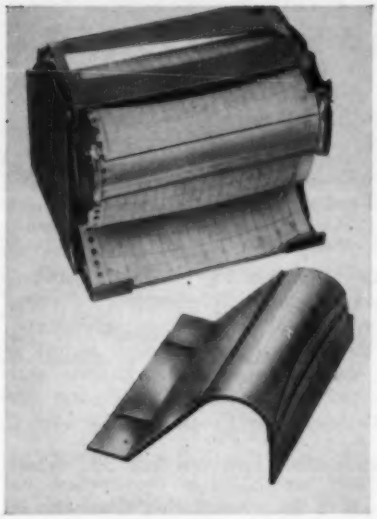
"When the results of the Round Robin Tests are completed and tabulated, it is hoped that the Flammability Committee can recommend one or more tests specifically for foamed plastics. . . ."

MANUFACTURING CHEMISTS ASSOCIATION

—". . . In recognition of the growing construction market for plastics, several years ago MCA centralized its activities in formation of its Plastics in Building Committee. This is staffed by a rotating group of technical men from major suppliers of plastics materials. Also recognizing the need for proper guidance in usage of plastics and serving the needs of the building industry, the MCA employed a full-time Director of Plastics in Building. . . .

"Looking only at the very recent past, a major activity of MCA was publication in mid-1960 of 'A Study of Fire Safety Aspects of Plastics in Building Construction'. This was report of a study commissioned by MCA at Southwest Research Institute. . . . It is to be expected that, as men entrusted with public safety, building officials should be cautious in permitting use of new materials such as plastics. And as most officials and builders haven't been

ONATE RESIN GOOD DIELECTRIC— AND MUCH MORE!



TRANSPARENCY of LEXAN resin is important in chart guide for recorder. LEXAN resin is the only transparent plastic able to withstand heat generated by internal lights. It is distortion-free at temperatures up to 270°F and self-extinguishing. Its extremely high impact strength eliminates cracking of guides. (The Foxboro Co.)

TOUGHNESS. Press-fitted into metal gear used in an electric drill, bushing of LEXAN polycarbomate resin provides safety from electric shock . . . helps eliminate need for additional grounding. Strength and creep resistance of LEXAN resin enables bushing to withstand torque and load requirements of drill. (Millers Falls Co.)

ARE YOU LOOKING FOR A PLASTIC THAT CAN REALLY TAKE IT?

To demonstrate the toughness of LEXAN resin, salesmen will sometimes slam and hammer a product made of the material. LEXAN has the highest impact strength of any plastic – amounting to 12-16 foot-pounds per inch of notch – and it usually emerges unscathed from encounters with such "merchandising stresses". It is a high-performance material, likewise, with regard to high-temperature behavior and dimensional stability.

Its many other advantages make it a priority material for thorough investigation by all designers, engineers and molders. We will be pleased to supply you with information on the properties, processing and end-uses of LEXAN resin. Don't hesitate to write to us. General Electric, Chemical Materials Department, Section MD-91, Pittsfield, Mass.

LEXAN®
Polycarbonate Resin
GENERAL ELECTRIC

trained as organic chemists, it is also to be expected that they would be confused by the multiplicity of polysyllabic generic and trademark names. In fact, the very multiplicity has been suspect as purposeful confusion.

"The MCA study at Southwest Research Institute was designed to provide information on the fire protection function of building elements and the fire safety provisions of building codes in relation to the use of plastics building materials. . . .

"The Southwest Research Institute Survey was the springboard for a current active project by MCA. One primer is being written to explain plastics to building officials, designers and constructors. This will summarize basic plastics terminology, and illustrate with thumbnail sketches of typical plastics and their usage.

"A second primer is already in advanced draft stage, to explain to plastics processors the needs of building industry and product approval procedures. This primer is being developed jointly with a technical committee of the Society of the Plastics Industry."

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—". . . To attempt to do a better job for the engineer, the Society and the industries that support our endeavors, the ASME Rubber and Plastics Division has taken the following steps:

1. We have recommended a material department in the Society to assist in compiling and publishing engineering data on materials, including rubber and plastics.
2. We have reorganized the Division to set up one permanent rotating committee to study and plan conferences, and another permanent rotating committee to study the problems of providing technical information to engineers, to upgrade the quality of papers, and to provide a well planned papers program in keeping with the conference theme.
3. We have arranged for the MCA book, 'Technical Data on Plastics,' . . . to be distributed through the ASME.
4. We have presented programs every year at the meetings of the Society, attempting to tell the Rubber and Plastics story to the Mechanical Engineering Profession. Perhaps of most value have been our review papers on rubber and plastics which contain a bibliography of the most significant writings in our field.
5. We have strengthened our research committee to the end that areas for study, and effort by our division can be determined and supported. . . ."

MASSACHUSETTS INSTITUTE OF TECHNOLOGY—"Research currently being carried on in the MIT Division of Building Engineering is principally in the fields of (1) molecular engineering, (2) time-environment behavior, (3) reinforced plastics, (4) composites and sandwiches, (5) foams. . . .

"Because the mechanical properties of plastics are intimately bound up with the molecular structure of the plastics materials, and the molecular structure, in turn, influences many other properties such as the tendency of the plastics material to be crystalline or amorphous, it is evident that an understanding of the influence of molecular structure is basic to all other studies of mechanical and physical properties. . . . .

"Because of their largely amorphous structure, high polymeric material such as plastics exhibit a strong time-dependent behavior which is, in turn, strongly influenced by environmental factors such as temperature. Consequently, to characterize the mechanical properties of plastics it is

necessary to ascertain their stress-strain-time environment behavior. . . .

"Work in reinforced plastics centers about (1) the interaction of single fibers and the surrounding matrix, and (2) the behavior of resins reinforced with masses of fibers in the form of random mats and woven fabrics. . . .

"Because of an increasing tendency to combine dissimilar materials into laminates so as to achieve the advantages of their combined behavior, it has been found desirable to make a careful analytical study of the behavior of such laminates. . . .

"Because of the increasing use of foams in the building field and because of their potential in structural sandwiches and other panels, a study of the characteristics of foam materials has been undertaken. Variations in density of the foam as well as in chemical species are being studied. . . .

"The research work in the laboratory has led to participation in the design and construction of a number of buildings incorporating plastics into the structure. Among them are the House of the Future now standing in Disneyland, the large radomes of reinforced plastics used on the DEW line, the plastics sidewall and the reinforced plastics sandwich roof of the United States Building at the Brussels World's Fair, and more recently the reinforced plastics pavilions at the United States Exhibition in Moscow. Currently, design and construction of prototype sections of a school designed for flexibility in arrangement, re-arrangement, and demountability are under way. The roof, in particular, incorporates plastics in the form of sandwich hyperbolic paraboloids with metal framing members for edges. Facings are reinforced plastics and the core a foamed-in-place rigid foam. Flexible foamed plastics may be used as an overlay on the roof to reduce noise induced by rain or hail. . . ."

AMERICAN SOCIETY FOR TESTING MATERIALS presented two reports—the first on Committee E-5 on Fire Tests of Materials and Construction and the second on Committee E-6 on Methods of Testing Building Constructions.

"ASTM Committee E-5 on Fire Tests of Materials and Construction is concerned with the development of methods for evaluating performance of building materials and constructions under fire exposure. As such it does not have subcommittees concerned with specific materials. Its active committees are functional in character and deal with tests for floors, walls, roof coverings, fire doors, and building finishes.

"True, a subcommittee on fire tests of lumber does exist but it has been quite inactive for several years. The subcommittee on Acoustical and Similar Finishes may have been created with a specific type of material in mind but its interests in fact have become more general. Recently a proposed flame-spread test was referred by Committee D20, Plastics, through Committee E-5 to the subcommittee on finishes. The proposal was to limit application of the test to plastics. After careful consideration of all of the facts known about this test, the subcommittee recommended its adoption as a tentative standard for research and development purposes only and applicable to all materials. This was the so-called radiant panel test method now known as ASTM E162-60T.

"A clarification of the scope of Committee E-5 has been proposed and is before the members on a letter ballot at the moment together with a general revision of the Committee by-laws. The distinction between types of fire tests and the relationship between Committee E-5 and other committees is clearly indicated. The scope of Committee interest is stated as:

'1. To develop methods of test for the determination of fire resistance and fire hazards of building materials and constructions for fire rating and fire hazard classification purposes . . .

'2. To aid in the development of methods of test for use in research and development of fire resistive materials and constructions.

'3. To review and coordinate methods of fire tests included in standards coming within the scope of other ASTM Technical Committees.' "

"In January 1946, Committee E-6 came to life and has grown in strength and stature for 15 years. . . .

"The present scope is:

'To formulate methods of test for building (including housing) construction, including elements, connections and assemblies, under actual or simulated service conditions, applicable to the evaluation of such factors as materials, design construction and fabrication, with special reference to the needs of building code and similar authorities with whom the Committee has liaison.'

"It is apparent from the scope that E-6 is primarily concerned with constructions, assemblies of construction and their elements as a unit of the whole rather than with individual materials.

"Whereas, D-20 on Plastics is concerned with plastics, their raw materials and the finished product made therefrom, E-6 is interested in plastics incorporated in a building construction and their influence on the end performance of the building construction. The same situation exists with respect to E-6 interest in other materials which are under the scope of other material committees.

"Currently the following 9 Subcommittees of E-6 actively engaged in maintaining and improving existing standards and developing new tentatives are:

Subcommittee I, on Segments of Wall, Floor, and Roof Construction . . .
Subcommittee II, on Durability . . .
Subcommittee III, on Sound Transmission . . .
Subcommittee IV, on Unit Masonry . . .
Subcommittee V, on Light Trusses . . .
Subcommittee VI, on Load Tests of Completed Structures . . .
Subcommittee VII, on Vapor Barriers Beneath Concrete Slabs on The Ground . . .
Subcommittee VIII, on Windows . . .
Subcommittee IX, on Curtain Walls . . .

HOME MANUFACTURERS ASSOCIATION. ". . . The paramount interest in the field of plastics today seems to be centered around the use of the foam plastics for residential wall panels. Building and trade magazines constantly present the stories of styrofoam and urethane activities. The National Association of Home Builders has, in cooperation with others, contributed greatly to fields testing foam panels in research houses and more recently for use in an actual trace-built housing project.

"With all things considered, our industry feels that it will be another 3 to 5 years before foam materials will be used to any great degree for exterior wall panels. It is expected, however, that this material will be employed for other uses such as interior non-load bearing partitions, etc., far in advance of the structural application. . . ."

SECTION NEWS

Members of the steering committee of the Delaware Valley (Trenton, N. J.) Section include, from left to right, front row: Clement Belusar, Vulcanized Rubber, Treasurer; Jack Pickering, Celanese, Board and Membership Chairman; Hal Elkin, Thiokol, Vice President; Clarence "Pip" Borden-Goodall, President; Paul A. Metz, Jr., Goodall, Secretary. Second row: Colin McBurney, RCA, Board and Credentials; Pierre Virly, Goodall, Board and Program Chairman; Robert Dobuski, Vulcanized Rubber, Board and House Chairman; Jay Dempsey, Thiokol, Board and Publicity Chairman; Chauncey De Pugh, Thiokol, Board and Membership Co-Chairman.

Delaware Valley

New Section Swings Into Action

P. A. Metz, Jr.
(Goodall Industries)

Moving swiftly into a program of meetings with the particular interests of its members in mind, the new section heard a talk on Celcon, "Acetyl Copolymer, a new Engineering Plastic," by M. Stadford Thompson, Celanese Polymer Co. A second talk by Foster J. Costner, Bakelite Co., Div. of Union Carbide Corp., covered, "Phenolic Resins as Curing Agents for Liquid Epoxy Resins."

The 74 men in attendance were invited to a Board Meeting that would take up the Charter Application and the setting up of committees that would establish standard Section procedures for the Fall.

The president, Clarence Borden, Goodall Industries, conducted the meeting.

Cleveland

Award for Cleveland Section

Sherman M. Crawford (left), Vice-Chairman of SPE's Administrative Board, presents the 1960 Region IV Membership Award Banner to James Jones (right), Section Membership Chairman, as Jack Pecktal (left center), 1960-1961 Section President, and Henry Dutot (right center), incoming Section President look on. The Cleveland Section won the Award by increasing its membership during 1960 by 12.6%, the greatest percentage increase of the nine SPE Sections in the East Central Region.

The Section will sponsor a Regional Technical Conference at the Cleveland Engineering Society on December 1, 1961. Subject, of particular interest in the plastics industry, "Plastics Screw-Injection Molding."

Western New England

Recreation and Relaxation on the June Agenda!

Merlin L. Evans
(Plax Corp.)

On June 14, under the direction of Art Staff of Koppers, the Farmington Country Club, Farmington, Conn., was the setting for a combination golf outing and ladies night, a fun-filled day for the WNE Section.

During the afternoon, 53 golfers competed in the Calloway Golf Tournament, and 95 members and guests were on hand for cocktails, a buffet dinner and dancing that evening.

Panel Discussion Opens New Season

Kick off night for the WNE 1961-1962 sessions was September 6, at Betty's Town House in Agawam, Mass. The topic for the evening—"Practical Aspects of Material Selection." A panel of three members with broad experience in material selection, included: George Davis, Development Engineer, Electric Storage Battery Co., Philadelphia, Pa.; Michael Lazar, Engineering Manager, Burndy Corp., Norwalk, Conn.; Ralph Mondano, President, Customs Materials, Inc., Chelmsford, Mass.

The following officers were elected for the 1961-62 program year. President, B. McNeill; 1st Vice President, R. Pollard; 2nd Vice President, L. Burkinshaw; Secretary, L. Barr; Treasurer, R. Sherman; Nat'l Councilman, R. Mazur.

The following program chairmen were appointed: Program, R. Bradbury; Education, P. Crane; Finance, A. Midyette; Publicity, M. Evans; House, R. Saxton; Membership, J. Flavin; Hospitality, T. Kurowski; Nominating, E. Duda.

New Directors elected are: Ray Bradbury, Allen Midyette, and Merlin Evans.

Toledo

Membership Improvement in the Great Lakes Region

Harold Holz, above, Regional Membership Chairman does the honors as Frank Reynolds, National President, SPE, joins in the applause at left. Ronald Wagner, Section President and Donald Bowlin, Membership Chairman display the banner.

Charter members of the Toledo Section pose with SPE National President, Frank Reynolds, center. Left to right, A. J. Gogel, R. Serrick, Mr. Reynolds, A. Kassay, and E. Kohler. Mr. Kassay is new section president.

Lowell Technological Institute Student Section

ENE Section President Guest at Dinner Meeting

Stephen L. Kaplan
(Lowell Technological Institute)

Guests of the Lowell Tech student chapter dinner meeting recently included Mr. A. Simon, president of the Eastern New England Section of SPE and Mr. H. Cookingham, Vice President. Several alumni of Lowell Tech's plastic courses were also present to keep the student members abreast of current industrial conditions.

New officers for the coming year include: Dennis Piermarini '62, President; Ronald Skribiski, '63, Vice President; Ronald Jalbert, '63. Treasurer; Richard Dauksys, '62, Recording Secretary; Steve Kaplan, '62, corresponding secretary; and Richard Crandall, '62, Parliamentarian.

Ablation effects was the subject of a speech and film May 4, by Augustus Walker, a former Lowell Tech professor, now head of plastics research at Avco.

MATERIALS AND PROCESS
Openings for
PLASTICS ENGINEERS

The Transport Division of The Boeing Company has a number of outstanding openings for plastics engineering specialists with a degree in one of the physical sciences and practical experience in plastics usage, evaluation, development or design. Salaries range from $7,000 to $12,000.

Areas of assignment include developmental and evaluation programs to determine choice and use of plastics materials in aircraft components and to provide process requirements to meet aircraft standards. Involved also is consultation with other engineering groups, manufacturing personnel and suppliers. Materials covered include reinforced plastics, all thermoplastics, synthetic fibers, foams and casting resins.

Send your resume, today, to Mr. Ivan G. Phillips, The Boeing Company, P. O. Box 707 - 82M, Renton, Washington. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

BOEING

Dr. Ewell To Speak at Buffalo RETEC

Dr. Raymond Ewell, Vice-Chancellor for Research at the University of Buffalo, will be the Luncheon speaker at the Buffalo Regional Technical Conference (RETEC) on Plastic Foams, to be held on October 5 at the Hotel Lafayette.

Dr. Ewell, who holds degrees from the University of Toledo, Purdue, George Washington and from Princeton where he earned his Ph.D. in chemistry, was awarded the Medal of Merit, the highest civilian decoration of the U.S. Government, for his work as Technical Aide in the National Defense Research Committee and Operations Analyst in the Air Force during World War II.

After the war, Dr. Ewell was with Shell Chemical and in 1948 served as manager of the Chemical Economics Service at Stanford Research Institute where he founded the Chemical Economics handbook. He was Assistant Director of the National Science Foundation from 1953-56 and on loan to the government of the Philippines as an adviser on industrial research. He went to India for the Ford Foundation as industrial development adviser to the Indian government serving also as an economic consultant on expansion of the fertilizer industry.

He has travelled extensively in Soviet Russia, visiting many universities, research institutes and factories, and has recently returned from a trip through Hungary and Czechoslovakia. A member of many scientific, economic and engineering societies, Dr. Ewell has published over 70 articles and chapters of books in economics and chemistry.

ABOUT MEMBERS

Jerome Formo, President of SPE in 1956, has been named Vice-President of the Plastics Corporation of America. A graduate of Augsburg College, '37, with a B.S. in Chemistry, Mr. Formo was Director of Plastics Research, Minneapolis-Honeywell Regulator Co. He helped form Plastics Institute of America early this year to carry on research and educational activities in plastics science.

The appointment of **Zachary N. Harris** as plant manager of the Dobeckmun Co., a division of Dow Chemical Co., Fresno, California, was made known. Mr. Harris was assistant plant manager. He holds a masters degree from M.I.T., and was with Extruders, Inc., the polyethylene film production firm purchased by Dow in 1953.

Six managerial and supervisory appointments in Plastics Sales, Polymers Department of Hercules Powder Co. have been announced. **Emmett E. Hixon,** manager, plastics sales; **Robert C. Clark,** product manager, "Hi-fax high-density polyethylene; **Robert D. Ullrich,** product manager, "Pro-fax" polypropylene; **George M. Taylor,** product supervisor, "Penton" chlorinated polyether; **William O. Bracken,** supervisor, market development and **Russell D. Hanna,** supervisor, technical service. Mr. Hixon joined Hercules in 1939, serving in many capacities and has been connected with plastics sales and allied industries since 1948. Mr. Clark joined Hercules in 1941 as a chemical engineer, and has been in sales since 1950. Mr. Ulrich became associated with the company in 1946 as a chemist at the Research Center. He has been serving as a supervisor of "Pro-fax" sales since 1958. Mr. Taylor, who was a senior technical representative, and with Hercules since 1951, has been closely connected with the commercial development of Penton. Mr. Bracken, with the company since 1939, is a past national president, vice president and councilman-at-large of SPE, and active in the plastics and coatings proceedings of the ACS and SPI. Mr. Hanna joined the company's plastics group in 1948 working with the plastics sales service laboratory in Parlin, N. J. since 1958.

Dr. Arthur M. Bueche has been appointed manager of the Chemistry Research Department of the General Electric Research Laboratory. Dr. Bueche, who holds a B.S. from the University of Michigan, '43 and a Ph.D. in chemistry from Cornell University, '47, served as a research associate at Cornell from 1947-50 when he joined the staff of the Research Laboratory.

The Research Department of Diamond Alkali Co. has announced the appointment of **Dr. Donald E. Hudgin** as associate director of research for polymers. Dr. Hudgin has been associated with several chemical companies since earning his B.S. degree in chemistry at Clemson College, his M.S. in organic chemistry, '40, and his doctorate from Purdue in 1947.

Donald A. Bullard has been elected a vice president of Northwest Plastics of Carolina, Inc., a wholly owned subsidiary of Northwest Plastics, Inc. of St. Paul. Mr. Bullard has served as general manager of the Gastonia, N. C., plant since 1959 and has been with the company for 20 years.

Howard T. Cusic has been elected President and Chief Executive Officer, U.S. Polymeric Chemicals, Inc., succeeding **Maarten W. Oudegeest** who is now chairman of the Board. Mr. Cusic has been Vice President and general manager, Eastern Division.

Lowell Technological Institute has awarded 12 degrees in the field of plastics engineering this past June. The graduates include: **Robert Chang,** China, **Donald T. Crowell,** who will join A. & C. Can Co., **Thomas F. Daly,** going to Plax Corp., **Russell J. Gould,** Esso Enjay Laboratories, **Richard F. Lacerte, Donald J. McQueen, William P. Moylan,** joining Koppers Co., **David B. Prout,** B. F. Goodrich Chemical Co.; **David A. Russell,** Monsanto Chemical Corp., **Charles A. Sullivan, Jr.,** Endicott Johnson Co., **William W. Tenero,** Texon, and **Anne J. Turcotte,** Dept. of Health, Education and Welfare.

Edward Singer, President, Victory Manufacturing Co., Chicago, Ill., has made known the sale of its Adult Games Line to Springfield Greene Industries, Inc., Springfield, Ohio, and the Plastic Housewares and Premium Line to Beacon Plastics Corp., Newton Highlands, Mass. Victory will continue in the custom molding of industrial parts and products for the manufacturing trade.

Alan S. Haisser is joining the petrochemical department, Continental Oil Co., as technical sales representative for the company's full line of plastic intermediates. Mr. Haisser was with Monsanto Chemical Co.

Albert G. H. Dietz, professor of building engineering, Massachusetts Institute of Technology, and **Gordon M. Kline,** chief, Organic and Fibrous Materials Division, National Bureau of Standards, have been elected to the Board of Directors, ASTM, to serve three years.

Heading up the newly formed sales service laboratory at Rexall Drug and Chemical Company's chemical division is **John H. Myers.** He will supervise the laboratory work required to back up Rexall's customer technical service program. Before joining Rexall Chemical, Mr. Myers was with Foster Grant Co., Inc., Celanese Corp. of America, Monsanto Chemical Co. and Union Carbide Plastics Co. He holds degrees from Drexel Institute of Technology and Stevens Institute of Technology.

James M. Lister heads a new sales office for the plastics division, Eastman Chemical Products, Inc., 4010 West 65 St., Minneapolis, Minn. He holds a B.S. in Chemical Engineering, Alabama Polytechnic Institute.

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• **A Wide Range** of yellows, tans, reds, browns, black . . . outstanding because they're high-color iron oxide pigments, with unusual purity, brightness, mass tone and tint clarity.

• **Plus Two New "Transparents"** —Mapico Yellow Low Opacity and Mapico Red Low Opacity.

• **Permanent Color** with exceptional strength . . . fine particle size.

• **Get the Facts** on all Mapico pigments for plastics . . . send us this coupon, today.

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380 Madison Avenue, N.Y. 17, N.Y.

Tell me more about Mapico for plastics!

Name.....

Position.....

Firm.....

Address.....

City.....Zone.....State.....

Warren Richards, President, Pharma Plastics, Inc., Baltimore, Md., is the winner of $500 in credit offered by Injection Molders Supply Co., Inc., at the recent SPI exhibit, to any one guessing the cubic content of the model Heating Cylinder of the Bented Reverse Flow Design displayed by the company.

George H. Light, Modern Plastics, Miami, Florida, and **A. H. Metz,** Commercial Plastics & Supply Corp., Pittsburgh, Pa., have been elected to serve one-year terms on the Board of Directors of the United Plastics Distributors Association.

DeBell & Richardson, Inc., have announced the appointment of **J. Robert Fisher** as senior project engineer, Product Development. He holds a B.S. in Chemical Engineering, University of Pittsburgh, '42, also attended Penn State for Advanced Plastics Technology. He has been associated with Swedish Crucible Steel, and Mine Safety Appliances Co.

David A. Finnegan becomes production coordinator for Photek, Inc., a Textron subsidiary in Providence, R. I. He will supervise the company's various production facilities. Formerly with Arkwright-Interlaken, Inc., Fiskeville, R. I., Mr. Finnegan is a graduate of Massachusetts Institute of Technology and Rensselaer Polytechnic Institute. He was also associated with M. Swift & Sons, Behr-Manning Div. of Norton, and other firms in chemical and engineering capacities.

Anver S. Suleiman has made known the formation of Panel Technology, a new organization that will serve the reinforced fiberglass panel industry on a consultant basis. Mr. Suleiman was former vice-president of Valco, Inc. The new company's headquarters are at St. Petersburg, Fla.

CYANAMID

PLASTICS ENGINEER

Excellent potential for professional growth is available for a Plastics Engineer in our expanding development laboratory.

Graduate Ch.E. or M.E. with minimum 2 years experience in the fabrication of thermosetting and thermoplastic materials. Experience in extrusion, mold and die design, and material evaluation necessary. Specific experience in the extrusion of acrylics highly desirable.

Responsibilities include supervision of test molding, extrusion of new materials as well as development of new methods and techniques. Technical service work and customer contacts also involved.

Write Employment Manager

AMERICAN CYANAMID COMPANY

Wallingford, Connecticut

Employment & Service Guide

POSITIONS OPEN

PLASTICS ENGINEER

Wanted by a rapidly growing plastics plant in the South. Need man with thorough experience in blow molding and injection molding, and willing to relocate if necessary. Excellent opportunity for personal growth and attractive salary available. Send resumes and references to Box 253, SPE Journal.

ENGINEER

Wonderful opportunity for man with a degree in Mechanical Engineering. Here is a chance to grow with a progressive company that is known for the excellence of its mold engineering. Stokes-Trenton Inc., 150 Enterprise Ave., Trenton, N. J.

SALES ENGINEER

New position with expanding worldwide long established Swiss company. Practical knowledge of injection molding, molds and material desirable. Will train the right man on Automatic screw injection molding machines designed in Switzerland and manufactured in Connecticut to U.S.A. Standards and requirements.

Submit resume to

THE BUHLER CORPORATION
Plastic Machinery Division
Charter Oak Boulevard
West Hartford, Connecticut
Adams 62317

MACHINERY SALES

Manufacturer of major line Plastic Injection Molding Equipment has protected areas available to Sales Reps in mid-West, South and far West. Experience in plastic industry necessary, liberal commission set-up, auxiliary equipment available. Write, stating qualifications, present lines carried, areas currently covered. Box No. 263, SPE JOURNAL.

PLASTICS ENGINEER as mgr. of new extrusion unit, long established firm. Experience in extrusion of vinyls, including rigids and die designs essential. Pleasant Long Island location. Box No. 271, SPE JOURNAL.

PLASTICS DEVELOPMENT ENGINEER

We have an attractive opening in our New Product Development Dept. for an engineer or chemist to work on fabrication techniques for new thermoplastics. B.S. minimum, 3-10 years broad experience in fabrication of plastics, especially extrusion. Send resume in confidence to Dr. David M. Clark, Director of Technical Recruiting, W. R. Grace & Co., Research Division, Clarksville, Md.

DIRECTOR RESEARCH

Growing Midwest Custom Molder looking for man to head Resin and Product Development Division. Applicant must have thorough knowledge of Thermo Setting and Thermo Plastic Material, as well as Compression Transfer and Injection Processes. Salary commensurate with ability. Send resume to Box 266, SPE Journal, 65 Prospect Street, Stamford, Connecticut.

AVISUN

PLASTICS

INTERNATIONAL MARKETING OPPORTUNITY

Rapidly expanding international markets have created singular growth opportunity for a man who has:

1—BS or AB in Science or Engineering (Chemical preferred)

2—At least 3 years' experience in marketing, technical service and/or technical development of thermoplastic raw materials.

3—A working knowledge of the chemical or plastics export market (language ability, particularly Spanish, preferred).

4—The capacity and desire to grow with a company which is at an early but accelerated stage of its development.

The man selected for this headquarters position must be sales-minded. He will represent AviSun in a given sphere of its international business and be responsible for technical liaison and service, from the home office and in the field, to AviSun's customers outside the United States. Compensation is open to meet individual experience—broad enough to provide for continued financial growth. Personal benefits are among the best. Replies will be held strictly confidential; each qualified candidate will be interviewed.

Submit complete resume in confidence to
Corporate Employment Manager

AVISUN CORPORATION*
1345 CHESTNUT STREET PHILADELPHIA 7, PA.

** A jointly-held affiliate of American Viscose Corporation and Sun Oil Company*

PLASTIC SALES ENGINEER

Immediate opening for Chemical Engineer or Chemist experienced in selling and servicing urea/melamine molding compounds. Strong sales background preferred but applicants with solid production experience in manufacture and use of thermoset materials will be considered. Interested applicants should reply, in confidence, by resume to—

RECRUITMENT MANAGER
AMERICAN VISCOSE CORP.
1617 Pennsylvania Boulevard
Philadelphia 3, Pa.

MANUFACTURERS REPS WANTED

To solicit OEM accounts on straight commission basis. We specialize in custom thermoforming and fabricating windshields, housings, containers, etc. Desire representation in Atlanta, Kansas City, West Coast and New York trade areas. Men with plastic forming knowledge required. Give complete resume, territory covered and references. Write Texstar Plastics, Division of the Texstar Corp., Box 1440, Fort Worth, Texas. Attn: Wm. K. McConnell, Sales Manager.

NEEDED BY ONE OF LARGEST U.S. PLASTIC INJECTION MOLDERS

PLANT SUPERINTENDENT with engineering background and practical experience in injection molding as well as pressure forming.
SALES MANAGER with knowledge of pressure and vacuum forming sales and distribution.

Substantial salary, incentive plan on increased business and part of net profits—only qualified individuals who are looking for a stable and profitable future need apply.

Complete resume and references required.

Address replies to: Box No. 268, SPE JOURNAL

PROJECT—PROCESS ENGINEERS

Our tremendous growth and planned for expansion has created openings for project and process engineers.

Qualifications:
B.S. or M.S. in chemical, mechanical or electrical engineering. 5-15 years of experience, preferably in plastics process field. Must have proven record of imagination and initiative.

Position Description:
Assignments in the extrusion production plant (semi-work) for polypropylene film, process and project assignments will be in debugging, production cost reduction, design of equipment improvements, installation of new equipment and equipment modification, maintenance problems, and assisting in training production personnel.
Operation includes; extrusion or orientation of films, coating, winding and slitting film, bag making, and printing.

Growth Opportunities:
Process and project engineering assignments in headquarters plant or branch plant, leading to engineering management or production management. Also excellent possibility for start-up assignments in overseas plants.

Send detailed resume to:

Charles W. Russell
Management Development Assistant
Kordite Company
Macedon, New York

All replies confidential.

PRODUCT DEVELOPMENT—PLASTICS

PROJECT LEADER

Major Oil Company with diversification program needs project leader for new Plastics Development Section in R & D. Must be capable of initiating important new projects and of making broad evaluations of new materials compared to competitive plastics. Applicants should have strong background in plastics and fabrication processes, with 3 to 10 years' experience in product development or application research. Exciting opportunity to contribute to the success of an important new activity. East Coast location.

Send resume and salary requirements to:

S-44, P. O. BOX 2066
Philadelphia 3, Pa.

PLASTICS ENGINEERS

Immediate openings in our new Research and Technical Service Center for Engineers familiar with polymer evaluation. We require a Bachelor's Degree and 3 to 10 years experience in plastics processing, physical testing, and/or customer service, particularly in polyolefins and polystyrene. Employment will offer challenging opportunities in applications research, technical service and resin investigation. Location in pleasant suburban Northern New Jersey.
Please send detailed resume with salary history and requirements. All replies held in strictest confidence.

Reply to:
REXALL CHEMICAL COMPANY
Dept. KK
P. O. Box 37
Paramus, New Jersey

VINYL COMPOUND & PLASTICIZERS

Well regarded basic manufacturer has career opening for young, technically competent salesman to sell expanding line of vinyl compound and plasticizers.

Excellent starting salary. Pleasant L. I. location. Box No. 272, SPE Journal.

TOOL DESIGNER

Growth opportunity with well established proprietary molder for man with heavy experience in plastic injection mold design. Knowledge of modern molding machines desirable. Send resume, include salary required to Sterling Plastics Co., 1140 Commerce Ave., Union, N. J.

POSITIONS WANTED

R & D ENGINEER

Chemical engineer, seven years diversified experience in research, development and sales service of thermoplastics materials, desires to utilize talents with progressive organization. Alert, aggressive, willing to relocate. Box No. 269, SPE JOURNAL.

EXTRUSION ENGINEER M.E. M.S.M.E.

Extensive, varied, proven 10 year record of successful solutions to thermoplastic extrusion problems connected with the manufacture of plastic insulated wire and cable. Broad general knowledge of a thermoplastic wire plant. Presently employed.

Now seeking a responsible technical position, at top level, in plastic research. Position need not be connected with wire and cable manufacture. All replies held in strictest confidence. Box No. 254, SPE JOURNAL.

PLASTICS ENGINEER

B.S. Ch. E. four years experience in thermoplastic and thermoset process and applications. Broad background includes product & market development plus some technical service. Previous experience in own business. Desires position with scope and responsibility. Resume on request. Box No. 252, SPE JOURNAL.

PLANT MANAGER

10 years experience in plastics extrusion of pipe, shapes, compounding, and scrap reclaiming. Knowledge of all phases of plant management and extrusion engineering. Interested in running extrusion plant from development to production. Age: 34. BME—Prefer N. Y.—N. J. area. Box No. 273, SPE JOURNAL.

PRODUCT MANAGER OR MARKET DEVELOPMENT

Proven ability in sales and in market research and development in organic chemicals, solvents, thermosetts and thermoplastics. Proficient in promoting to corporate top management or selling production operator. A combination of major corporation know-how and small company self-reliance. B.S. in Chemical Engineering. Box No. 256, SPE JOURNAL.

MANUFACTURING EXECUTIVE

Former Vice-President Manufacturing. Production, Quality, Tool and Product Design. Cost Reduction. Sales Engineering. Desires Position Manufacturing, Design & Sales Engineering. Experience: Injection, Extrusion, Tube Blowing, Casting and Polyester Laminates. Age 42. Experience 22 years. Presently Employed. Will Relocate. Reply Box No. 229, SPE JOURNAL.

CLASSIFIED INFORMATION AND RATES

SPE members in good standing are entitled to a total of three no-charge "Positions Wanted" advertisements within any 12-month period, each ad (not to exceed 50 words) should include training, experience, location desired; headline (not to exceed 3 words) must state job description. Additional words will be charged @ 25¢. *Do not* submit resumes: none are kept on file.

Last day for inserting all classified ads is the first day of the month preceding date of publication, except for display size ads which close on the 15th of month preceding issue date.

"Positions Open" and "Positions Wanted" —$12.50 per column inch, 2¼ inches wide. (35 characters per line; 7 lines per inch). Minimum charge: $12.50. Pre-publication contact, known as the "Availability File"—$5 service charge on "Positions Open"; no charge to SPE members. *See adjacent box for a description of how it works.* "Products and Services" and "Business Opportunities" —$20.00 per inch. Minimum charge: $20.00.

All ads include one bold face caption line. Additional caption lines @ $2.50 extra per line. Boxed ads (4-sided rule)—$3.00 extra. Agency commission allowed *only* on ads 5 inches or more in depth. Display ads of 1/16 page or more are charged at regular advertising space rates. No ¼ page or vertical ⅓ page ads published within Employment Service Guide section. Typesetting (non-commissionable) will be charged at cost.

HOW OUR "AVAILABILITY FILE" WORKS

If you are a company, or an SPE member who will be advertising in SPE JOURNAL, you can receive copies of those classified ads of potential interest to you *before* they are actually published in the Journal, provided that these advertisers have also indicated their interest in the same procedure. This pre-publication contact is what we call our "Availability File". All you have to do to participate is to sign the return postcard we send you upon receipt of your advertising insertion. When your card is returned, the ads are sent to you as they come in, up to publication date.

PROJECT ENGINEER—ADMINISTRATOR

ChE with fifteen years broad plastic engineering experience. R&D, project coordination, product application and development, technical service on elastomers and plastics including adhesives, laminates, embeddments, castings, moldings, coatings, foams. Desires challenging position with rising organization. North Jersey first choice. Resume. Box No. 270, SPE Journal.

THERMOPLASTICS DEVELOPMENT ENGINEER

Strong in product and process development. 13 years laboratory and plant experience, primarily film converting and wirecoating. Sound practical and theoretical knowledge of thermoplastics, extrusion processes and equipment. M.-Chem.E., polymer chemistry minor patents. Want responsible development position requiring creative ability with solid background. Box No. 264, SPE JOURNAL.

PLASTICS ENGINEER

B.S. degree in Chemical Engineering, 10 years broad experience in process development, injection molding, blown film extrusion, polymer evaluation and compounding. Desires responsible position in market development or applications development. Box No. 274, SPE JOURNAL.

CHALLENGING POSITION

desired in growth company. Five years experience in marketing epoxy resins. Experience with formulation of epoxy coatings, adhesives, electrical insulation, flooring compounds, etc. Creative, responsible leader with administrative ability. B.S. Chemical Engineering. Age 30. Will relocate. Limited travel only. Resume. Box No. 265, SPE JOURNAL.

BLOW MOLDING CONSULTANT

B.S. in M.E., B.S. in B.A., M.B.A., 35 years old, 15 years experience. Will set up a blow molding operation, recommend machinery, install it, design and supply utilities, design and procure molds and finishing equipment, train personnel. References supplied. Box No. 267, SPE JOURNAL.

PRODUCTS & SERVICES

INJECTION • BLOWING
COMPRESSION • TRANSFERS

MOLDS

Quick Delivery, Cheapest Prices

DANISH MOULD ENGINEERING

Osterbrogade 54D

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COPENHAGEN, DENMARK

Addendum to

Castings Bibliography*

The following additional references were supplied by Alex. Javitz, Special Features Editor, ELECTROTECHNOLOGY.

Casting Resins

Electro-Technology (formerly Electrical Manufacturing)

Cast Resin Embedments of Circuit Subunits and Components, A. E. Javitz, **September 1951**

Selecting an Embedment System for Electronic Components, D. G. Heitert and H. W. Niemann, **May 1952**

British Developments in Embedded and Printed Circuits, G. W. A. Dummer, **May 1953**

Conveyorized Assembly for Component Embedment, J. C. Souter, **August 1954**

Epoxy Embedded Circuits and Components, A. E. Javitz, **April 1955**

Embedment Techniques for Subminiaturization, H. E. Blanke, **May 1955**

Automatic Machine for Cast-Resin Applications, J. E. Sensi and P. J. Franklin, **September 1955**

Polyester Casting Resins for Rigid Insulating Parts, R. G. Black, **October 1955**

Problems in Casting Electronic Components, H. G. Manfield, **October 1955**

Environmental Tests for Embedded Electronic Units, C. A. Harper, **December 1956**

Copper-Inert Flexible Coil Encapsulation, R. S. Norman, D. E. Crawford and A. A. Kessel, **November 1956**

Evaluation Tests for Epoxy Casting Systems, M. V. Goodyear and J. P. Hornburg, **September 1957**

High Temperature Solventless Encapsulating Resins, D. W. Lewis, **March 1957**

Resin-Embedment Process Control for Optimum Electronic Package Design, C. A. Harper, **January 1957**

Plastics and Ceramic Foams for Electronic Applications, William R. Cuming, **May 1958**

Vacuum-Molded Epoxy Cast-Resin Applications, H. R. Lucas, **April 1958**

Environmental Evaluation Data for Silicone Encapsulants, D. F. Christensen, **July 1960**

Cast-Resin Applications in Switchgear and Transformers, Wilhelm Johann Karl Oburger, **June 1960**

Materials and Techniques for Resin-Encapsulated Missile Circuits, Staff Report, **May 1960**

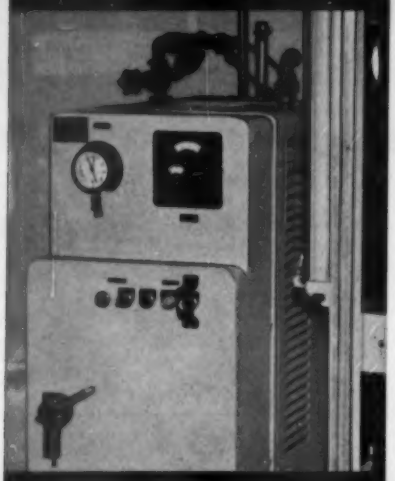
An Improved Epoxy-Resin System for Electronic Embedments, B. H. Mueller and C. A. Harper, **February 1960**

Thermally Conductive Cast-Resin Compounds for Heat Dissipation, C. A. Harper, **April 1961**

Stability of Epoxy-Encapsulated Magnet-Wire Systems—An Analysis of Compatibility Factors, A. E. Javitz, **March 1961**

*** May 1961 SPE Journal, page 478**

IBM ENDICOTT PLANT USES
STERLCO TEMPERATURE
CONTROL UNITS FOR ACCURATE
MONITORING OF PLASTIC MOLDS



Stator Blocks for the IBM 407 Accounting Machine are molded on a Logan Press, with a Sterlco Model 6016 maintaining accurate mold temperatures.

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CHOICE OF AMERICA'S LEADING PLASTIC MOLDERS

The Sterlco Model 6016, selected by the IBM Plastics Laboratory, Endicott, New York, to assure accuracy of delicate plastic components, is a single zone circulating unit with a temperature range of 100° to 550° F. Heat transfer fluid temperature is maintained by an immersion type heater of 12 KW capacity. Circulating pump is heavy duty, slow speed positive displacement type. There are Sterlco units to provide the same efficient, low-cost service for you . . . whatever your temperature control needs may be!

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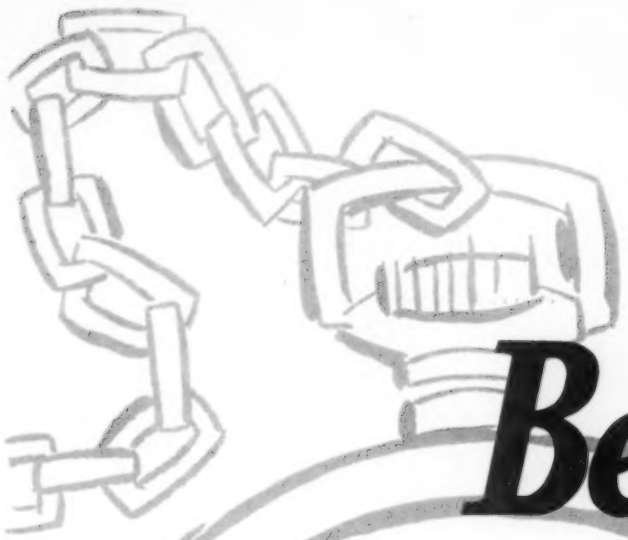

Production time is of the essence . . .

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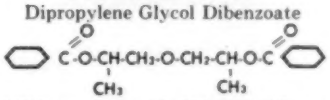
Confidence in the efficiency of production is assured with Benzoflex Plasticizers. Why? Because of the consistent quality and performance of Benzoflex, which enables you to speed up your production cycle . . . molding and extruding equipment can be run at lower temperatures. Benzoflex is the proven low temperature fusing plasticizer which will improve your products while reducing manufacturing costs.
An order to Tennessee Products and Chemical Corporation means top quality plus prompt delivery.

BENZOFLEX® 9-88

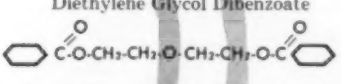
Dipropylene Glycol Dibenzoate



Benzoflex 9-88 is one of the most widely used of those primary plasticizers not based on phthalic anhydride. It is compatible with all types of polyvinyl chloride homopolymers and copolymers, as well as many other resin systems.
Benzoflex 9-88 is a high solvating plasticizer, offering significant advantages in the processing of highly filled vinyl stocks such as flooring and extrusions. This rapid solvation can effectively increase production rates, lower processing temperatures—often as much as 50°F. Either of these measures is of help in maintaining resin stability.
In unfilled compositions the use of Benzoflex 9-88 produces film, sheet or tubing of brilliant clarity and high surface gloss. It has excellent permanency, with exceptional resistance to hydrocarbon extraction.

BENZOFLEX® 2-45

Diethylene Glycol Dibenzoate



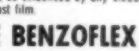
Benzoflex 2-45 is quite similar to Benzoflex 9-88, though somewhat more efficient in vinyl systems. Although it has a melting point of 28°C, it has never been observed to crystallize in compounded formulations, even at sub-zero temperatures.
Benzoflex 2-45 is recommended for use in adhesives—especially those based on polyvinyl acetate emulsions.

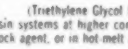
COMPATIBILITY CHART

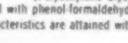
	Percent Benzoflex 9-88			Percent Benzoflex 2-45		
	50	25	10	50	25	10
Polyvinyl Chloride	C	C	C	C	C	C
Polyvinyl Chloride-Acetate	C	C	C	C	C	C
Polyvinyl Acetate	C	C	C	C	C	C
Polyvinyl Butyral	C	C	C	1	C	C
Polystyrene	1	C	C	1	1	1
Cellulose Acetate	1	1	1	1	1	1
Cellulose Acetate-Butyrate	C	C	C	C	C	C
Nitrocellulose	C	C	C	C	C	C
Ethyl Cellulose	C	C	C	C	C	C
Polymethyl Methacrylate	C	C	C	C	C	C

C—Compatible 1—Incompatible, as evidenced by any cloudiness or oiliness of cast film.

OTHER MEMBERS OF THE BENZOFLEX SERIES

Benzoflex® T-150  (Triethylene Glycol Dibenzoate), being a solid plasticizer, has a tendency to crystallize and bloom in most resin systems at higher concentrations. However, at low levels, this property may be used to advantage as an anti-block agent, or in hot-melt adhesives.

Benzoflex® P-200  (Polyethylene Glycol 200 Dibenzoate), while compatible with most resin systems, has been particularly useful with phenol-formaldehyde resin, especially in laminating applications. Improved flexure and heat distortion characteristics are attained without sacrifice of electrical properties.

Benzoflex® P-600  (Polyethylene Glycol 600 Dibenzoate), is useful as a modifier of phenol-formaldehyde resin and as anti-powdering agent in synthetic floor waxes.

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AVISUN POLYPROPYLENE GIVES "FORM-FIT" COMFORT TO ALLADIN PLASTIC CHAIRS

First Injection Molded Chair

For this major advance in furniture making, Alladin Plastics, Gardena, Cal., uses AviSun polypropylene. Here's why: • *Amazing strength*—In Alladin's thumping, rocking torture test, AviSun Impact Grade Polypropylene outlasted all materials tested—endured up to 375 times longer. • *Supple comfort*—like that of upholstered furniture. • *Chemical and stain resistance*—to detergents, alcohols, oils, foods and cleaners—unharmed by sun and weather. • *Mold cycles*—as fast as 60 seconds with no post-mold aging. • Get the facts on how polypropylene can upgrade *your* product from: AviSun Corporation, 1345 Chestnut Street, Philadelphia 7, Pa. • In Canada: Courtaulds Plastics Canada, Limited.

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